# Economic Assessment of Sanitation Interventions in Yunnan Province, People's Republic of China

## A six-country study conducted in Cambodia, China, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI)

**September 2012**

wsp water and sanitation program

The Water and Sanitation Program is a multi-donor partnership administered by the World Bank to support poor people in obtaining affordable, safe, and sustainable access to water and sanitation services.

**THE WORLD BANK**
**Water and Sanitation Program**
**East Asia & the Pacific Regional Office**
Indonesia Stock Exchange Building Tower II, 13th Fl.
Jl. Jend. Sudirman Kav. 52-53
Jakarta 12190 Indonesia
Tel: (62-21) 5299 3003
Fax: (62 21) 5299 3004

# Economic Assessment of Sanitation Interventions in Yunnan Province, People's Republic of China

## A six-country study conducted in Cambodia, China, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI)

# Executive Summary

## A. INTRODUCTION

The "Economics of Sanitation Initiative" (ESI) in Yunnan, China, is part of a study conducted by the World Bank's Water and Sanitation Program in East Asia. As one of the underdeveloped western provinces of China, Yunnan has achieved huge progress in sanitation improvement. Since the early 1990s, the Chinese government has set sanitation improvement as one of the top priorities in the national development plan. As a result, the access to sanitary latrines and toilets in both rural and urban areas has increased rapidly. In rural areas of Yunnan, access to improved sanitary latrines has increased from 2.4% in 1990 to 53.7% in 2008. In urban areas of China, coverage with improved private facilities has increased by 10 percentage points from 48% to 58% since 1990, and a further 30% of the urban population using shared facilities in 2008.

Still, in comparison with the rest of China, Yunnan lags in access to improved sanitation and faces significant challenges in catching up with the pace of development in eastern provinces. The average national coverage with improved sanitary latrines (including shared) was 59.7% for rural areas in 2008, while Yunnan reached only 53.7%. In the year 2007, only 30% of urban areas in Yunnan were equipped with sewerage systems, in comparison with 70% nationally. In Yunnan Province, 6.4% of the total population of 45 million is living under the poverty line, which mostly lacks access to safe and sanitary latrines.

The main barrier to achieving the national sanitation targets lies in the efficiency and effectiveness of sanitation investments. This study aims to provide evidence for decision making on future options for sustainable sanitation development, focusing on the selection of economically viable technology options, as well as efficient delivery modes. In doing so, the study attempts to demonstrate the benefits associated with sanitation, particularly in the less developed and rural parts of China such as Yunnan Province, and the importance of sanitation in promoting economic development. By providing decision makers at national and provincial levels with comprehensive information to support policies on public sanitation investment, the goal of this study is to increase the efficiency of sanitation investments.

## B. STUDY AIMS AND METHODS

This study evaluates the costs and benefits of technical sanitation options and sanitation programs in Yunnan Province. Sanitation options evaluated in the study include the facilities to collect and convey human excreta, household wastewater treatment and related hygiene practices. The benefits of sanitation evaluated include health, water quality, time to access sanitation facilities, external environment, reuse of human excreta, quality of life improvement and other intangible benefits such as privacy, cleanliness and comfort. The costs of sanitation measured include investment costs and recurrent costs (operations and maintenance). The study compares the costs and benefits of alternative improved sanitation options over the expected life of each technology, to estimate efficiency of alternative sanitation options. The "optimal" performance of technologies assumes 100% adoption rates and correct utilization by the beneficiaries, while the "actual" performance is adjusted downwards based on adoption rates observed in the field.

## C. DATA SOURCES AND STUDY SITES

This study focuses on recent sanitation programs in Yunnan Province, implemented and co-financed by the government and other partners. For the study, sanitation options in eight different sites throughout Yunnan Province were selected, representing urban, peri-urban and rural areas as well as different socio-economic levels and cultural settings.

The three rural sites include: a) villages in Luquan county's mountainous rural villages (R1), located near Yunlong reservoir, wich supplies drinking water to Kunming city and where Yi and MIao are the dominant ethinic groups; b) Dali Shangguan (R2) lakeside plain, with the Bai ethnic group; and c) villages in Qiubei county (R3) which are both laekside and mountainous, and where the dominantt ethnic groups are Zhuang, Miao and Yi. Shared and pit latrines are widely used in rural areas together with improved sanitation options like biogas units, septic tanks and urine-diverting dehydration toilets (UDDT). Open defecation is still commonly practiced in mountainous rural villages.

The three urban sites represent different classes of urbanization: a) Kunming (U1), the provincial capital of Yunnan located in the center of the province, with high population density and water scarcity challenges; b) Dali (U2), a prefectural capital, located on Erhai Lake in western Yunnan Province. Flush toilets with sewerage are the main sanitation option in these two cities; c) Qiubei (U3), a county capital, is located in the Karst area by Puzhehe Lake in southern Yunnan Province. Public and private flush toilets with septic tanks and pit latrines are Qiubei's main sanitation options.

The two peri-urban sites include a) Kunyang town of Jinning County (PU1), a small town located on the southern side of Dianchi Lake and part of the wider urban agglomeration of Kunming city; and b) Dali Zhoucheng (PU2), a rapidly urbanizing rural area, located on Erhai Lake near Dali, with Bai as the dominant ethnic group. Public dry toilets, pit latrines, shared latrines, UDDTs, and septic tanks are widely used in these peri-urban areas.

## D. RESULTS

### D1. COST-BENEFIT ANALYSIS RESULTS

The economic returns on all improved sanitation options are significant in all the sites evaluated, when compared with no access to basic sanitation. To simplify the presentation, the benefit-cost ratio (BCR) is the cost-benefit indicator presented in this executive summary, while cost per disability-adjusted life-year (DALY) is the main cost-effectiveness indicator presented. The reader is referred to Chapter 8 for a full presentation of the efficiency indicators.

In rural areas, all the sanitation options have very high BCR as follows: UDDT (9.4), private pit latrines (8.5), 3-in-1 biogas units (6.9), shared toilets (6.0), and private septic tanks (4.7). The cost-effectiveness of these measures range from US$272 per DALY averted for UDDT to US$479 per DALY averted for septic tanks. As a health intervention, these results indicate sanitation as a highly cost-effective intervention, represented by the cost per DALY being less than the GDP per capita (see Figure D)[1]. However, there is a significant loss of efficiency between ideal and actual performance of each sanitation option, as shown in Figure A.

In urban areas, the BCR of sanitation options are as follows: public toilets (4.5), septic tanks (2.8), and sewerage (1.9). Other less commonly applied options in urban areas – pit latrines and UDDT – have higher economic returns, but are generally less relevant for the majority of urban areas in China. Cost-effectiveness ratios are US$558 per DALY averted for public toilets, US$886 per DALY averted for septic tanks, and US$1,385 per DALY averted for sewerage. While these figures represent a higher cost than that of rural areas for the same health return, they are still under the benchmark for a cost-effective intervention. As in rural areas, there is a significant loss of efficiency between ideal and actual program performance in urban areas, as shown in Figure B.

In peri-urban areas, the BCR of sanitation options are lower compared with rural areas, but still significant, as follows: UDDT (8.7), private latrines (7.6), septic tanks (6.1) and shared latrines (4.2). As in urban and rural areas, there is a significant loss of efficiency between ideal and actual program performance in peri-urban areas (see Figure C).

[1] World Health Organization

**FIGURE A:** IDEAL AND ACTUAL BENEFIT-COST RATIOS OF RURAL SANITATION OPTIONS

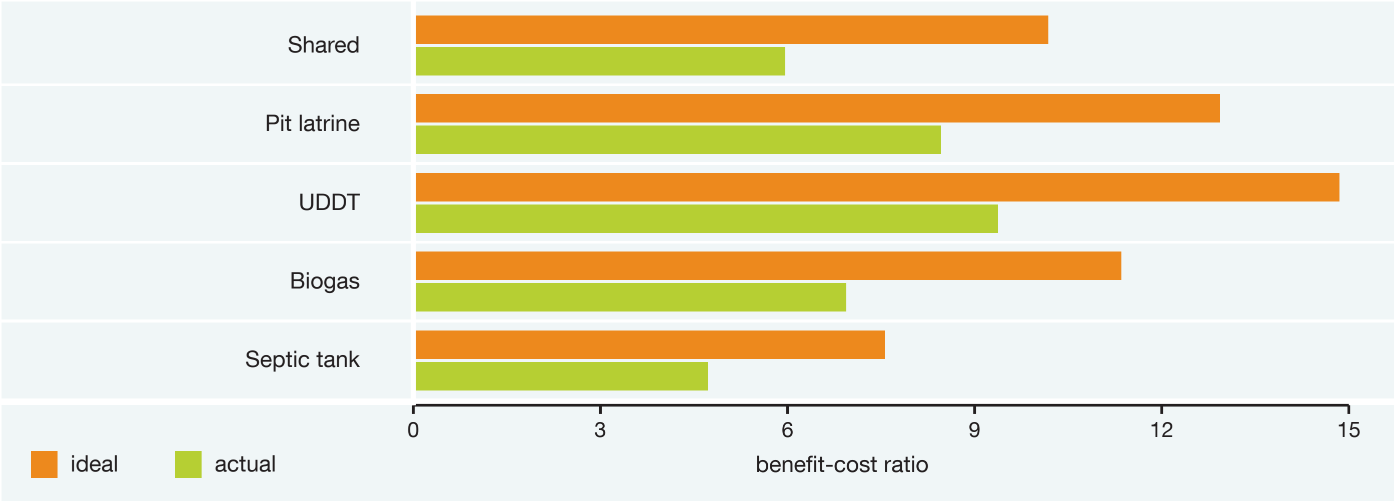
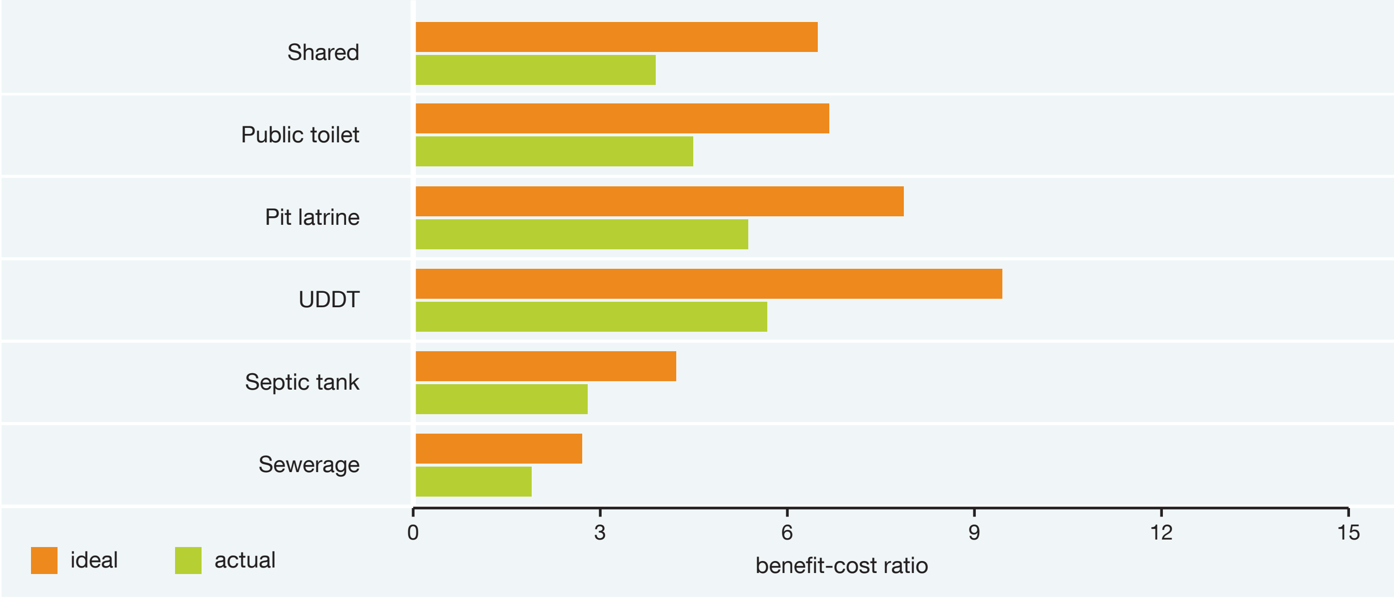



**FIGURE B:** IDEAL AND ACTUAL BENEFIT-COST RATIOS OF URBAN SANITATION OPTIONS




Note: "Ideal" ratios reflect the scenario where all sanitation options delivered are fully and correctly utilized by households, according to their function. "Actual" ratios reflect the observed utilization rates from the survey data.

**FIGURE C:** IDEAL AND ACTUAL BENEFIT-COST RATIOS OF PERI-URBAN SANITATION OPTIONS

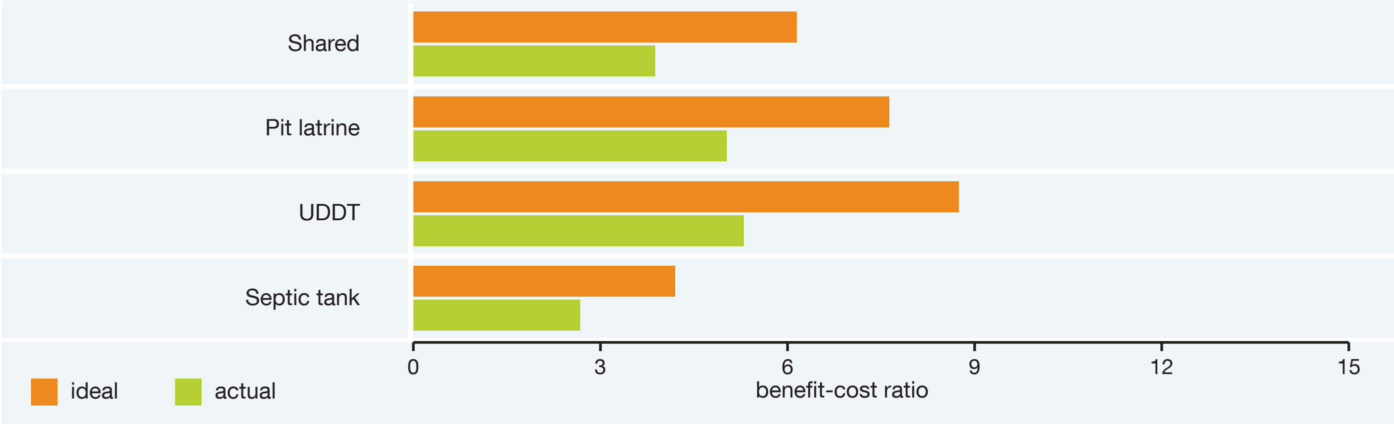
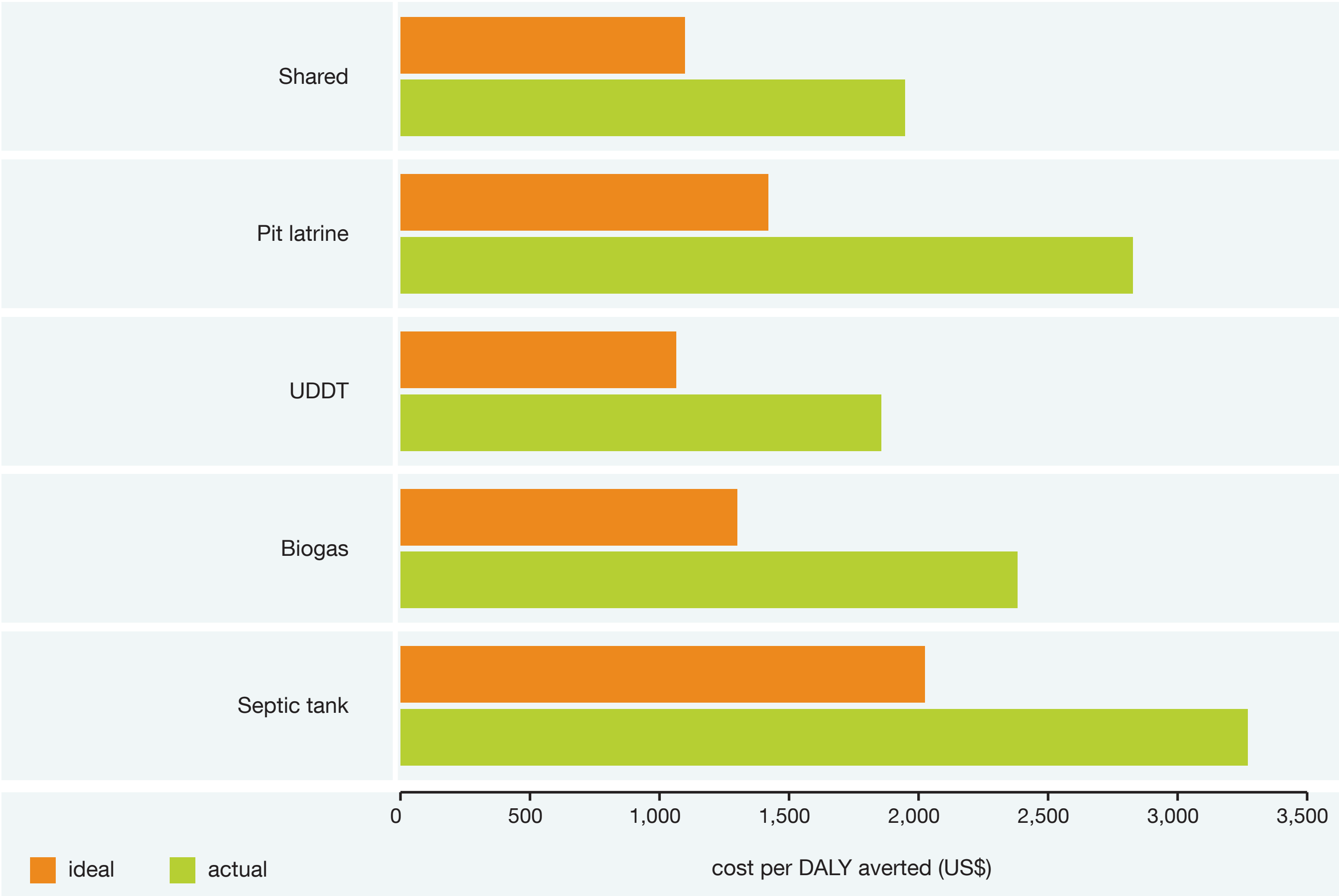


**FIGURE D:** COST PER DALY AVERTED OF SANITATION OPTIONS IN RURAL SITES (US$)




Note: "Ideal" ratios reflect the scenario where all sanitation options delivered are fully and correctly utilized by households, according to their function. "Actual" ratios reflect the observed utilization rates from the survey data.

As an example of the efficiency of moving up the sanitation ladder from one improved option to another, results from rural Qiubei site are presented in Table A. The ideal scenario is compared. The efficiency of improved sanitation moving from shared toilet to private pit latrine, UDDT and biogas are 3.8, 4.5 and 7.3, respectively. The incremental efficiency of improved pit latrines is significant in comparison with the "shared toilet." Moving from pit latrine to options with higher health benefits and reuse benefits leads to a BCR of 4.5 (UDDT), 5.0 (biogas) and 2.1 (septic tank). Cost-effectiveness ratios range from US$230 per DALY averted for moving from shared toilet to biogas, to US$557 per DALY averted for moving from pit latrine to septic tank.

## D2. COSTS

A summary of sanitation option costs is provided in Table B. In rural areas, the average investment cost per rural household for shared toilet, pit latrine and UDDT ranges from US$135 to US$185. The average cost of the 3-in-1 biogas units is US$361, and the average cost of septic tanks is US$507. Average annual recurrent costs per household are US$15 for hygiene and US$16 to US$43 for the different sanitation options. Total equivalent annual costs per household (thus annualizing investment costs and including annual recurrent costs) averages between US$29 and US$68 per household.

In urban areas, average investment cost per household for hygiene is US$41. The cost for shared and public toilets, pit latrines and UDDT ranges from US$138 to US$189 per household. Septic tanks (with septage management) and sewerage range from US$522 to US$685. Average annual recurrent cost per household ranges from US$16 for shared toilets to US$72 for sewerage. Average annual cost per household calculated for the whole life period ranges from US$27 for hygiene to US$105 for sewerage. Capital

**TABLE A:** RURAL AREA EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARING DIFFERENT POINTS ON THE SANITATION LADDER (QIUBEI RURAL SITE)

| Efficiency measures | Moving from shared toilet to | | | Moving from pit latrine to | | |
|---|---|---|---|---|---|---|
| | Pit latrine | EcoSan UDDT | Biogas | EcoSan UDDT | Biogas | Septic tank + STF |
| COST-BENEFIT MEASURES | | | | | | |
| Benefits per US$ input | 3.8 | 4.5 | 7.3 | 4.5 | 5.0 | 2.1 |
| Internal rate of return (%) | >100% | >100% | >100% | >100% | >100% | 40% |
| Payback period (years) | 1.2 | <1.0 | <1.0 | <1.0 | 1.6 | 3.9 |
| Net present value ($) | 164 | 270 | 339 | 270 | 315 | 142 |
| COST-EFFECTIVENESS MEASURES | | | | | | |
| Cost per DALY averted ($) | na | 325 | 230 | 325 | 335 | 557 |
| Cost per case averted ($) | na | 3.1 | 2.2 | 3.1 | 3.2 | 5.3 |
| Cost per death averted ($) | na | 5,840 | 4,139 | 5,840 | 6,026 | 10,010 |

Note: na: not calculated due to improved pit latrine assumed to have the same health impact as improved shared latrine.
STF - septage treatment facility.

**TABLE B:** COSTS PER HOUSEHOLD IN RURAL AND URBAN AREAS – INVESTMENT AND RECURRENT (US$)

| | Cost Item | Shared toilet | Public toilet | Pit latrine | EcoSan | Biogas | Septic tank | Septic tank+ STF | Sewerage |
|---|---|---|---|---|---|---|---|---|---|
| Rural | Capital investment | 134.7 | - | 159.1 | 165.7 | 336.0 | 484.0 | - | - |
| | Program investment | 0.0 | - | 0.0 | 19.0 | 25.5 | 23.3 | - | - |
| | Recurrent (O&M) | 15.7 | - | 19.3 | 24.7 | 31.6 | 42.6 | - | - |
| | Average annual | 29.2 | - | 35.3 | 43.2 | 67.8 | 68.0 | - | - |
| Urban | Capital | 133.2 | 187.4 | 164.0 | 168.3 | - | 497.9 | 537.2 | 629.8 |
| | Program | 4.4 | 13.9 | 0.0 | 20.5 | - | 24.2 | 27.8 | 29.5 |
| | Recurrent | 16.1 | 28.5 | 19.5 | 29.3 | - | 46.0 | 60.0 | 72.3 |
| | Average annual | 29.9 | 48.7 | 35.9 | 48.2 | - | 72.1 | 88.3 | 105.2 |

"-" no data

investment accounts for between 24 and 45% of the total cost, program cost a maximum of 4%, and the percentage of recurrent cost ranges from 54 to 74%.

In peri-urban areas (not presented in the table), average investment cost per household is around US$145 for shared toilet, pit latrine and UDDT; rising to US$520 for septic tank with septage treatment. The average recurrent cost per peri-urban household averages US$45 for a septic tank. Average annual cost calculated for the whole life period of a septic tank is US$72, assuming a 20-year life span.

The costs of moving up the sanitation ladder depend on the starting option, and whether an entirely new facility needs to be built, or whether the "higher" ladder option can utilize some or all of the existing hardware. For example, moving from a shared toilet to a private pit latrine, or from a pit latrine to a UDDT, will need the full investment cost. Moving from a pit latrine to biogas can use some of the existing facilities, thus costing less than US$200 in rural areas. Moving from septic tank to sewerage also involves a partial cost saving as the toilet does not need to be replaced – hence requiring an investment cost of US$769 instead of US$2,170.

## D3. HEALTH BENEFITS

To estimate health benefits, the study determined the health costs of illnesses, health treatment, and loss of productivity, and estimated the total avoided costs by applying risk reduction proportions from international scientific literature.

The disease burden of diarrhea and helminthes is high in China, with a heavier burden in rural areas than in peri-urban and urban areas. From international research, the links between environmental risk factors and malnutrition, and diseases resulting from malnutrition, have been made. The most important of these, acute lower respiratory infections (ALRI) in children under five, were among those included in this study. In rural sites, it is estimated there are 1.9 cases of disease per person per year, 16 DALYs per 1,000 people, and an annual risk of death of 0.92 per 1,000 people due to poor sanitation and hygiene. In urban areas the rates are lower, at 1.4 cases of disease per person, 13 DALYs per 1,000 people, and an annual risk of death of 0.67 per 1,000 people. In peri-urban areas the rate is more similar to urban than to rural areas, at 1.5 cases of disease per person, 12 DALYs per 1,000 people, and an annual risk of death of 0.69 per 1,000 people. A high proportion of disease cases and disease burden overall is in the under five population; hence households with one or more young children will have higher health returns from improved sanitation and hygiene practices than households with no young children.

The majority of people seek care from public providers and private clinics, depending on the costs of travel and treatment, and the proximity of public hospitals. According to the ESI survey, 20% of rural households choose public providers, 30% private clinics, 20% informal care, and 9% self-treatment. In comparison, 40% of urban households choose public providers and 20% self-treatment.

Health-related productivity cost is calculated based on disease incidence (disease cases per person per year), the time of inactivity due to disease, and the opportunity cost of time. The result shows that the productivity loss due to disease is highest among the rural population, followed by the peri-urban and urban population, respectively (see Figure E).

Premature mortality costs are calculated based on the mortality rate and cost per premature death. Children under five have the highest premature mortality cost. Diarrheal disease causes the highest premature mortality cost. For the total value of premature mortality cost caused by the diseases, the 0-4 age group in rural areas has the highest average mortality cost per person per year at US$280, compared to urban areas (US$254) and peri-urban areas (US$166).

The total health costs of poor sanitation include medical, productivity, and premature mortality costs. The reduction in health risks and costs has been documented internationally with each step up the sanitation ladder, with pit latrines (with partial isolation) reducing diarrheal disease incidences by 36% from open defecation (OD), and sanitation options with full isolation or treatment of excreta reduces diarrheal disease incidence by 56%. Hygiene interventions carried out alongside these sanitation improvements add further to the health risk reduction.

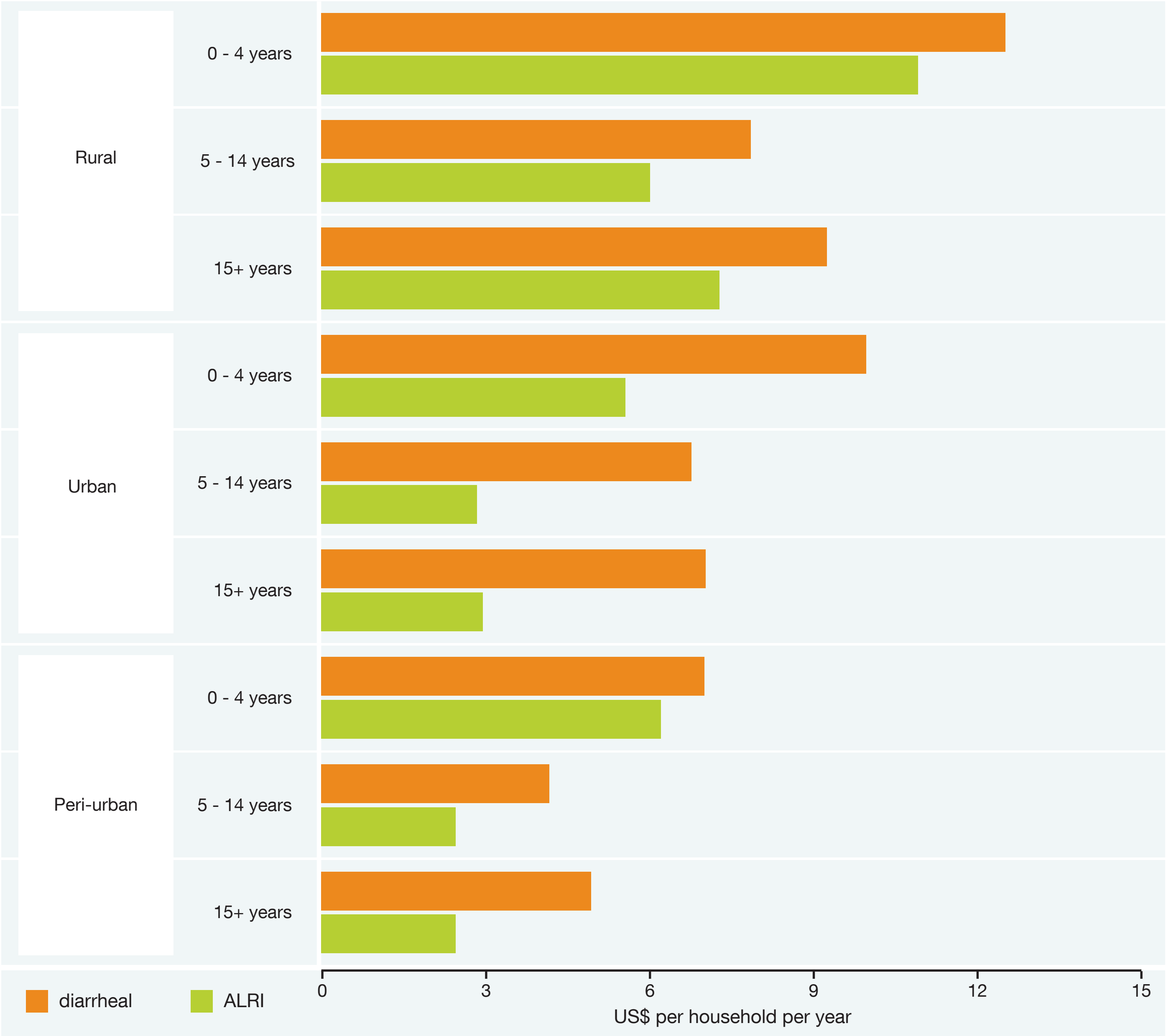
Each step up the sanitation ladder results in an avoided cost. The avoided cost of moving from OD to basic sanitation for rural households averages US$280 per household per year. In urban areas, moving from OD to sewerage systems may avert an average US$277 per household, while moving from basic sanitation to sewerage averts an average US$106 per household. In peri-urban areas, moving from OD to basic sanitation may avert an average US$195 per household (refer to Table C).

**TABLE C:** AVERTED HEALTH COSTS OF IMPROVED SANITATION (US$)

| Cost items | Costs averted (US$) | | | | |
|---|---|---|---|---|---|
| | Rural (OD to Step 1) | Urban (OD to Step 2) | Urban (OD to Step 1) | Urban (Step 1 to Step 2) | Peri-urban (OD to Step 1) |
| Health care | 33.9 | 36.4 | 23.0 | 13.4 | 26.7 |
| Productivity | 38.4 | 33.8 | 20.8 | 13.0 | 25.1 |
| Premature mortality | 207.5 | 206.3 | 126.9 | 79.3 | 143.7 |
| **Total** | **279.8** | **276.5** | **169.7** | **105.7** | **195.5** |

Source: ESI study. Step 1: partial isolation or treatment of excreta; Step 2: full isolation or treatment of excreta.

**FIGURE E:** COMPARISON OF THE PRODUCTIVITY COST BETWEEN STUDY SITES OF ACUTE LOWER RESPIRATORY INFECTIONS (ALRI) AND DIARRHEAL DISEASE 2008 (US$ PER HOUSEHOLD PER YEAR)




## D4. WATER BENEFITS

Although Yunnan Province is rich in water resources, the geographic distribution of water resources is uneven. In the most populated and economically developed regions, such as the center of the province, the average water resource per capita is 700m$^3$, while in Dianchi watershed, it is 276m$^3$ per capita. The source of drinking water also differs by region. In Dali, 87% of drinking water comes from ground water while in Qiubei ground water comprises only 9% of the total.

Some water bodies in Yunnan Province have been seriously affected by poor sanitation practices, including the lack of latrines, latrine options that lead to pollution of ground and surface waters, and the release of untreated wastewater into water bodies. Drinking water quality in both urban areas and rural sites is not up to the drinking water standard, as measured by various water quality indicators. Water samples collected for the ESI survey from rural and urban field sites in Qiubei, as well as water quality data collected from government sources, indicate high values for E.coli (Escherichiacoli), $NH_3$-N (Ammonia-nitrogen), TN (Total Nitrogen) and TP (Total phosphorus), which indicate a high influent loading from domestic sources. Related to that, the turbidity, conductivity, and chemical oxygen demand (COD) values are also high. The level of ammonium nitrogen in rural shallow wells is higher than that in urban shallow wells, pointing to the greater impact of human and animal wastes in rural areas on ground water. In villages where animal husbandry is a common practice, the influence of animal waste on ground water might be even more serious than human excreta.

The field survey results show that full isolation of excreta (or a high degree of isolation, according to Chinese standards, such as septic tanks) is high in all sites, as of 67% of the total investigated households (see Figure F). However, pollution from poor household management of sewage (i.e. draining untreated, or inadequately treated, into the ground or surface water bodies) is high in rural areas R2 and R3 and peri-urban area PRU2.

As well as human excreta, draining of general household wastewater (gray water) into the ground or water bodies is a relatively common practice in all rural, peri-urban and urban sites, and is practiced by an average of 43% of households investigated. Also, not all treated wastewater is treated to high standards, so some pollution is originating from wastewater treatment plants.

The annual costs of water access, as well as the dominant sources of drinking water, are shown in Table D. On average, rural, urban and peri-urban sites all have high access to piped water, at 66%, 86% and 93% respectively. Average annual cost per household for water sources ranges from US$11 for accessing unprotected sources in rural areas to US$52 for piped water in peri-urban sites. The figures include tariffs and the opportunity cost of time spent collecting water from off-plot sources.

While drinking water sources can often be exposed to pollution risks, the widespread cultural practice of treating drinking water, regardless of its quality, significantly reduces the risks of waterborne diseases. Boiling is the dominant practice for treating water at home, while some households use filtration. There is little difference among the water source access of rural, peri-urban and urban sites. Water treatment costs more in urban sites, as shown in Table E. Under a high coverage of sanitation and hence water protection, some households can be assumed to stop household treatment, while others may use cheaper or more environmentally friendly home treatment methods. Table E shows the predicted annual costs averted due to the improved quality of water sources.

## D5. ACCESS TIME SAVINGS

The average rural household without a private latrine or toilet has to spend the equivalent of 37.6 days to access sanitation (travel plus waiting time) while urban and peri-urban households without a toilet spend 24.0 and 36.6 days average per year, respectively, using shared or public toilets. Owning their own toilet averts these access times, which when valued at 30% of the average wage rate for adults and 15% for children leads to equivalent economic savings of US$60 in urban, US$64 in peri-urban, and US$44 in rural households every year.

## D6. EXCRETA REUSE BENEFITS

Human excreta collected from latrines or septic tanks and treated before being reused as fertilizer to improve soil quality and promote growth of crops is common practice in rural areas of Yunnan Province. This study has evaluated the economic value of safely reusing human excreta as fertilizer through UDDT and producing gas from human and animal excreta through biogas units. The result of ESI's household surveys shows that reuse of human excreta can save an average US$47 annually per household if excreta is reused as fertilizer, and an average US$77 annually per household if excreta is processed through 8 cubic meter biogas units and used for lighting and cooking energy. In the latter case, animal manure is commonly collected and fed into the biogas digester, and provides a significant proportion of the raw materials needed for successful functioning of the digester.

## D7. INTANGIBLE BENEFITS OF SANITATION OPTIONS

The study conducted 24 focus group discussions (FGDs), involving over 100 participants of whom 60% were women. The topics for FGDs include the population's understanding of sanitation; factors explaining current sanitation practices; preferences for selection of different sanitation options; and decision making processes for current and future sanitation options. Results are also presented from

**FIGURE F:** ISOLATION LEVEL OF SANITATION OPTIONS THROUGH THE FIELD SITES

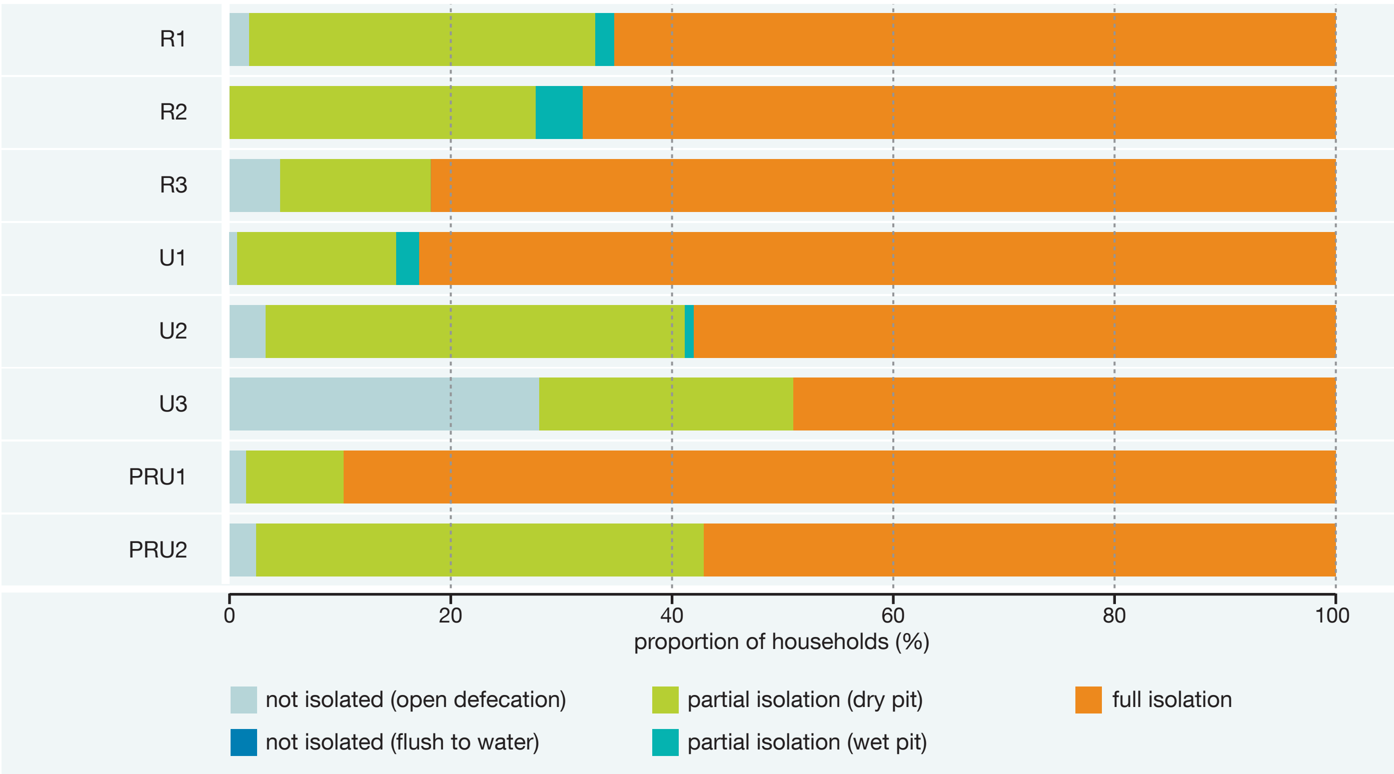



**TABLE D:** WATER ACCESS AND TREATMENT COST

| Water source | Indicator | Rural sites | Urban sites | Peri-urban sites |
|---|---|---|---|---|
| Piped water | % access | 66% | 86% | 93% |
| | Average annual access cost (US$) | 29 | 29 | 52 |
| Non-piped protected | % access | 20% | 11% | 4% |
| | Average annual access cost (US$) | 34 | 20 | 16 |
| Unprotected | % access | 14% | 3% | 3% |
| | Average annual access cost (US$) | 11 | 41 | 32 |

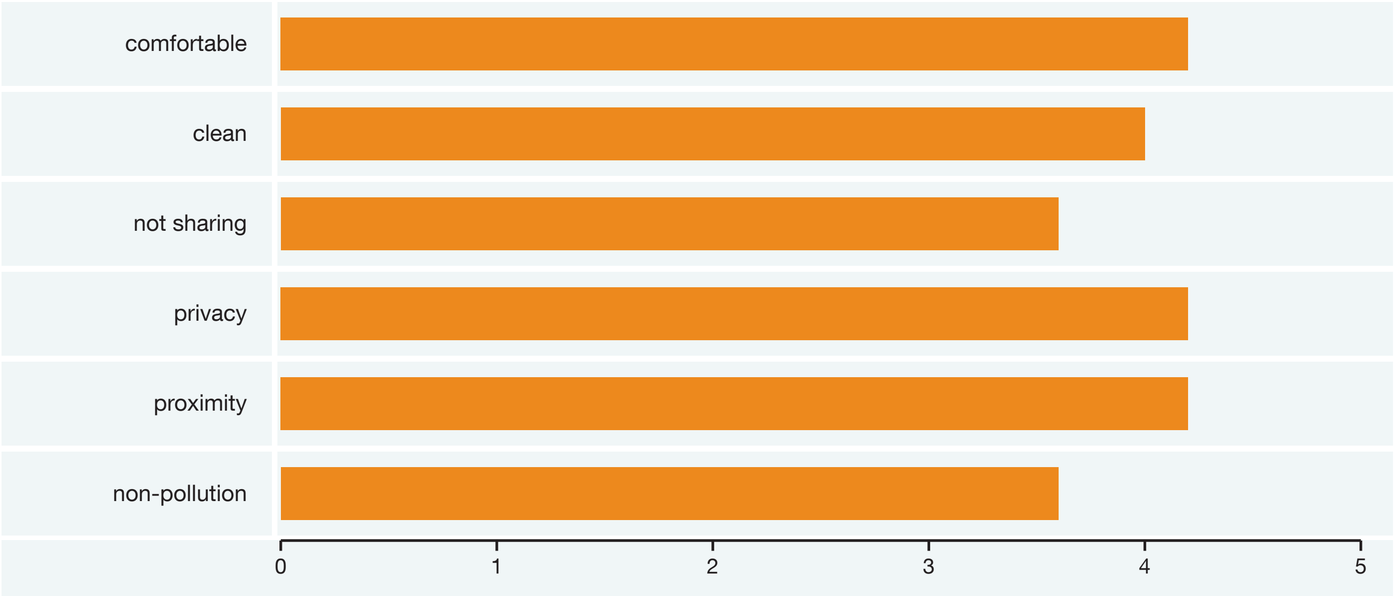
**TABLE E:** WATER ACCESS AND HOUSEHOLD TREATMENT COSTS INCURRED AND AVERTED (US$, 2009)

| Variable | Annual average costs per household (US$) | | | Annual average costs averted per household following 100% sanitation coverage (US$) | | |
|---|---|---|---|---|---|---|
| | Rural | Peri-urban | Urban | Rural | Peri-urban | Urban |
| Water source access | 84 | 76 | 83 | 2.1 | 1.7 | 1.8 |
| Water treatment | 27 | 32 | 50 | 7.3 | 7.0 | 6.7 |

questions in the household survey that focused on these intangible aspects of sanitation.

The main reasons some households did not possess toilets are lack of investment capital, lack of a proper site for construction, and the need for a radical behavior change in using and maintaining the new sanitation facility. As shown in Figure G, the two most important factors for households without their own toilets to get a toilet are "comfort" and "proximity," cited by 83% and 82% of survey respondents, respectively. "Privacy" is important for 77% of households, "cleanliness" for 70% of households, "non-pollution" for 58% of households, and "not having to share" for 53% of households. Figure G shows the average scores (out of a maximum of 5) for the importance of different features of improved sanitation.

**FIGURE G:** PROPORTION OF IMPORTANT AND VERY IMPORTANT REASONS TO GET A LATRINE FOR THOSE CURRENTLY WITHOUT (%) (1 = NOT IMPORTANT; 5 = VERY IMPORTANT)




In rural areas, most respondents consider improved private pit latrines to be most appropriate for them as it can collect excreta and is easy to clean, with the 3-in-1 biogas unit the option of second choice. UDDT is not widely accepted by most households and is ranked in third place because of poor quality and the requirement for a change of habits in using and maintaining it. Urban households with private flush toilets, such as those in Kunming and Qiubei, have a high level of satisfaction with their toilet options (over 4 out of 5). Among the urban households using public toilets, most of them believe that ownership of their own toilet would be more comfortable and they would expect to have a flush toilet. Peri-urban households using public toilets prefer flush toilets connected to septic tanks or sewerage, and desire to build such a toilet if conditions permit. Those using public toilets in Kunming peri-urban and Dali city have the least satisfaction for their current sanitation option, at less than 3 out of a maximum score of 5 .

## D8. EXTERNAL ENVIRONMENT

"External" environment refers to the area outside the toilet and is not related to toilet-going itself. It includes living areas, public areas, and private land, which can all be affected by open defecation practices and unimproved toilet options.

Figure H shows the ranking of different factors that potentially affect the quality of life related to the environment. All environmental quality average scores range between 2.4 and 3.6 (out of a maximum of 5) for all sites, suggesting poor to moderate environmental quality. Among the reasons for the spoiled environment, open sewage and rubbish are ranked as the worst performing with an average score of below 3.

Perceptions can, however, vary. For example, the survey in Dali Old Town suggests that women are much more sensitive to a poor environment, citing the presence of human and animal excrement, domestic garbage and urine in the back streets of the town. Female respondents think that the poor external environment affects the health of the residents as well as the reputation of Dali Old Town as a famous tourist site. On the other hand, male respondents think the environment is reasonably clean. However, both men and women say they are willing to pay for better public waste management.

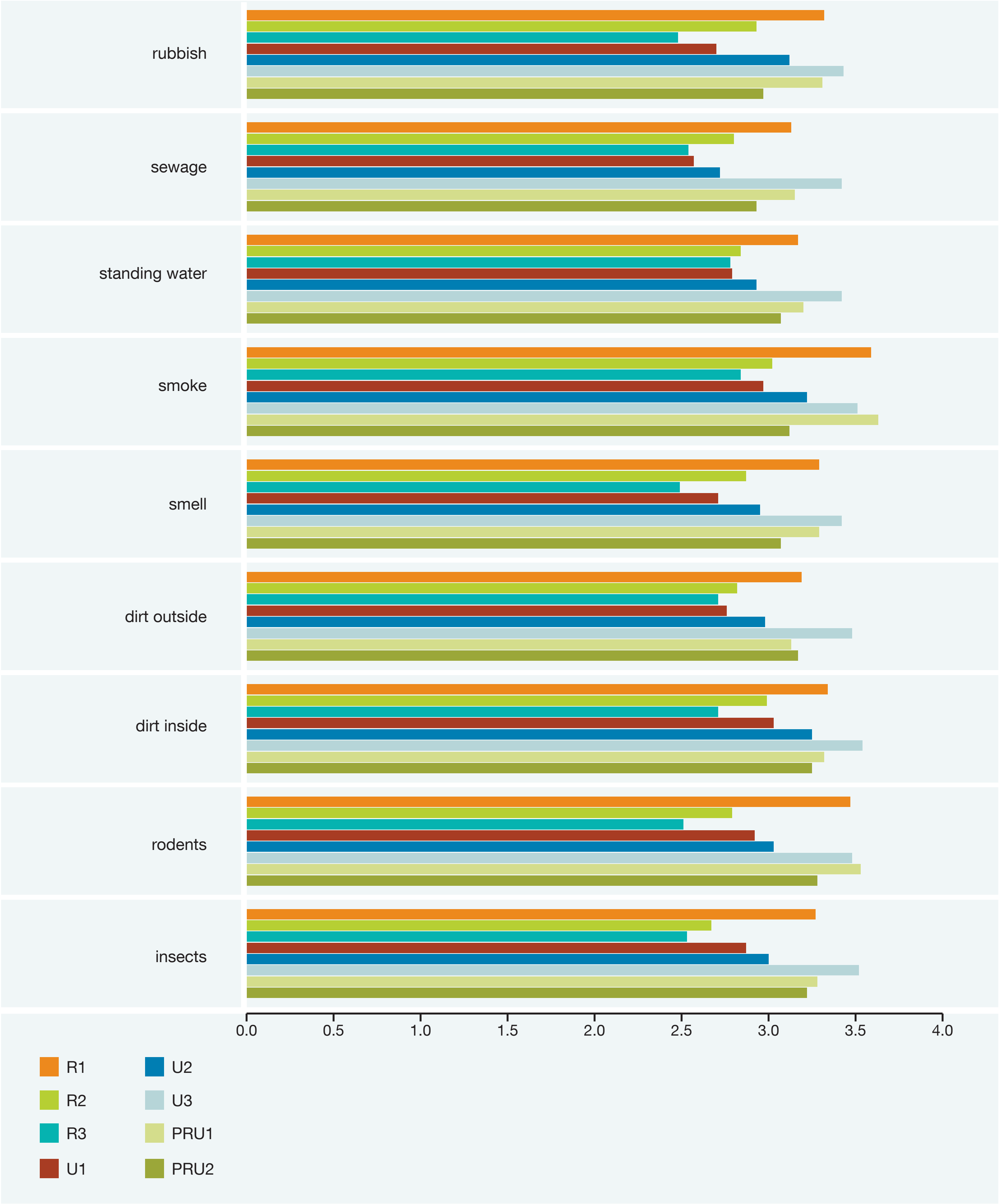
## D9. SUMMARY

Table F shows the summary breakdown of benefits. In rural areas, households could save an average of US$331 annually for health, water and access time benefits of improved basic sanitation, with an additional reuse value of US$47 from UDDT or US$77 for biogas. Reuse of human excreta from pit latrines and septic tanks, and sludge from treatment plants, also has a net positive economic value – if handled properly and fully treated to avoid transmission of disease. In urban areas, the savings are US$344, compared with US$303 in peri-urban areas. Using the criterion of the benefit-cost ratio to reflect efficiency, the UDDT has the best performance. However, taking into account user preferences and the actual performance efficiency (the non-use of UDDTs), normal latrines are the most effective option in rural areas. In urban and peri-urban areas, off-site sanitation options become more necessary and with the proper implementation lead to the best environmental as well as health performance. However, due to the high costs of septic tanks and wastewater management, the benefit-cost ratios are less favorable, but still economically viable (with benefit-cost ratio greater than 1.0).

**TABLE F:** SUMMARY OF LOCAL IMPACTS OF SANITATION IMPROVEMENT

| Benefit | Benefits of improved sanitation and hygiene | | | |
|---|---|---|---|---|
| | Quantitative benefit (US$/household, annual) | | | Qualitative or Other Benefit |
| | **Rural** | **Urban** | **Peri-urban** | |
| HEALTH | | | | |
| Health burden/quality of life<br>• Cases/person<br>• Mortality/1000 population<br>• DALYs/1000 population | <br>1.93<br>0.92<br><br>16.0 | <br>1.43<br>0.67<br><br>13.0 | <br>1.47<br>0.69<br><br>12.0 | • Avoided pain and discomfort from illness (captured partially in the DALY losses)<br>• Avoided costs from other diseases associated with poor sanitation |
| **Health costs averted** | **280** | **277** | **196** | *Refer to Tables 7 to 12 and Figures 10 to 13.* |
| Health care | | | | |
| OD to Basic | 34 | | 27 | |
| OD to Sewerage | | 36 | | |
| Productivity costs averted | | | | |
| OD to Basic | 38 | | 25 | |
| OD to Sewerage | | 34 | | |
| Mortality costs averted | | | | |
| OD to Basic | 207 | | 144 | |
| OD to Sewerage | | 206 | | |
| WATER | | | | |
| Access cost savings | 2 | 2 | 2 | Improved water quality (smell, appearance, less contaminants) for drinking, domestic purposes, recreation and other. *Refer to Figure 16* |
| Treatment cost savings | 7 | 7 | 7 | |
| **Access time** | **44** | **60** | **88** | • Avoided discomfort from having to queue<br>• Households without toilets mostly consider "comfort" and "proximity" the most important reasons to get a toilet<br>• Time loss associated with urination is excluded<br>*Refer to Table 18, Table 19 and Figure 28* |
| **Intangibles** | nc | nc | nc | • Comfort associated with use of clean toilets<br>• Pride in having a toilet, especially if expensive<br>• Privacy and not being seen going to the toilet<br>• Safety of women and children<br>• Confidence to invite guests to the house<br>*Refer to Figure 31 and Table 25* |
| **External environment** | - | - | - | • Cleaner surrounding areas<br>• Less exposure to insects and rodents<br>*Refer to Annex Table F5* |
| **Reuse: composting** | 47 | - | - | • Cleaner surroundings and averted water pollution |
| **Reuse: biogas unit** | 77 | - | - | |

**FIGURE H:** PERCEPTIONS OF ENVIRONMENTAL SANITATION STATE, BY TYPE (1= VERY BAD; 5 = VERY GOOD)



The most important contributor to the quantified benefits is related to health improvements of improved sanitation. Benefits of improved sanitation and hygiene can avoid the health burden by reducing disease cases, mortality, and DALYs, and averting annual health cost per household of US$280 in rural areas, US$277 in urban and US$196 in peri-urban areas. This includes financial gains related to less health care seeking, gained productive time due to improved health, and saved lives. The latter contributes most significantly to overall health economic gains. Improved sanitation can increase water quality, and thus can save water access costs and treatment costs ranging from US$8.5 per household in urban site to US$9.3 per household annually in rural areas. Improved sanitation can release time for productive activities, with an average value of US$44, US$60 and US$88 per household annually in rural, urban and peri-urban areas, respectively. Other intangible benefits are also perceived by the users. Reuse of the products of improved sanitation also save US$47 annually per household by composting and US$77 annually per household by using biogas, in rural areas. These benefits are summarized in Table F.

## D10. PROGRAM PERFORMANCE

The main indicators of program efficiency include usage rate of improved sanitation, cleanliness of the latrine or toilets, access time to toilets, reuse of human excreta, satisfaction toward improved sanitation and the quality of the external environment. Public participation and good governance are crucial for the success of the sanitation and hygiene program (see Table G).

The program approach used to deliver sanitation interventions is an important determinant of the effectiveness of the interventions. In rural areas of China, the promotion of improved sanitation facilities is conducted mainly by the government, using a supply-driven approach with little consideration of local preference. As a result, the actual efficiency results presented in this study suggest the interventions are not reaching their potential, as many households do not utilize their toilets correctly or all the time. In rural areas, there are cases of "demand-led" sanitation where households voluntarily invest in their own toilet, with little outside influence. For this reason, the economic efficiency of pit latrines is high. Also, the technology is simple, and the human excreta is commonly reused in the fields. The reuse value has not been added to the pit latrine option, as there are concerns about whether households are knowledgeable about good practice in relation to safe handling and treatment of human excreta.

In urban areas, the original "technology planning" approach is commonly utilized, with property developers having a major influence over the choice and design of sanitation options. Flush toilets with connection to sewerage are most commonly chosen. However, the household often has the option of choosing the actual toilet type. As most urban households have little choice but to use their own

**TABLE G:** SELECTED KEY INDICATORS FOR PROGRAM EFFECTIVENESS (FROM A HOUSEHOLD SURVEY)

| Impact | Indicator area |
|---|---|
| FOR QUANTITATIVE COST-BENEFIT ANALYSIS TO ESTIMATE ACTUAL EFFICIENCY | |
| Health (sanitation) | 78% household members using improved toilet instead of previous unimproved option |
| Health (hygiene) | 75% households answered "yes" to washing hands after defecation<br>16% improved latrines in which there were signs of feces around toilet |
| Access time | 78% household members using own toilet instead of off-plot options |
| Reuse | 71% households with UDDT or biogas use the bi-products (fertilizer or biogas) |
| FOR QUALITATIVE ANALYSIS | |
| Intangibles | Average score of 3.6 (out of maximum score of 5) for all relevant satisfaction questions |
| External environment | Average score of 3.0 (out of maximum score of 5) for 2 external environment questions relating to sewage (visibility and smell) |

toilet when they are at home, the effectiveness of sanitation options in urban areas is correspondingly high, and "actual" economic performance is reasonable.

Program design and implementation modality play an important role in the overall effectiveness and impact on households and hence efficiency. The project design is crucial for site and technology selection, considering the scarcity of land, the preferences and cultural habits of the inhabitants, and the environmental conditions. Whether the target groups have the opportunity to choose and make decisions on the sanitation option is crucial in affecting the participation of the users in construction, use and maintenance. In the field sites, most of the households have little say over the sanitation options chosen. Programs should also consider the users' ability to pay. As most of the projects need some matching funds from households, the poorer households are unable to invest in their own toilet facility. As a result, some of them gave up participating in the projects.

Each sanitation option has its own advantages as well as limitations for wide-scale adoption, summarized in Table H. Three-in-one biogas toilets require a mild climate and a minimum amount of excreta to generate methane. The UDDT is more suitable for the areas with a dry climate and low temperatures. The three-grid septic tank is not suitable for the areas with a high water table. Centralized wastewater treatment technology is not appropriate to extend in the sparsely populated rural and mountainous areas. The high construction and operation costs of centralized wastewater treatment leads to a less favorable economic performance compared to on-site sanitation.

## E. RECOMMENDATIONS

This study has shown that all sanitation options have a highly favorable economic return, but they all experience a drop in performance under actual program conditions. Since improved sanitation options have been shown to be highly efficient in economic terms, populations without access to basic sanitation should be prioritized by sanitation and hygiene programs. Comparison of economic performance among different sanitation options should form part of the decision on which sanitation type to choose. Government subsidies should be first allocated to ensure populations, especially the poor and disadvantaged, receive basic access.

**TABLE H:** ADVANTAGES AND DISADVANTAGES OF SANITATION OPTIONS FOR SCALING UP

| Sanitation types | Advantages | Disadvantages |
|---|---|---|
| Pit latrine | • Low construction cost<br>• Simple technology<br>• Human excreta commonly extracted from the pit and reused as fertilizer | • Hygiene status of the toilet is often poor<br>• Often pollutes the environment, especially in the rainy season<br>• Human excreta is not safely treated, causing a higher health risk |
| Biogas | • Saves energy for lighting and cooking<br>• Provides highly efficient and safe organic fertilizers<br>• Saves money<br>• Reduces pollution to the environment<br>• Convenient, safe and healthy | • High construction cost<br>• Occupies space in homestead<br>• Limited by availability of animal manure<br>• Not suitable for cold climates<br>• Needs good post-phase management, including maintenance |
| UDDT | • Provides highly efficient and safe organic fertilizers<br>• Reduces pollution to the environment | • Not seen as convenient by users<br>• Smells if not properly maintained<br>• Needs time input of household and resources (such as rice husk/sawdust)<br>• Higher investment and recurrent cost than simple pit latrine |
| Water flushing toilet (with septic tank or sewerage) | • Clean<br>• Hygienic<br>• Convenient | • High construction cost and operational cost<br>• Needs a large amount of water<br>• Needs off-site wastewater treatment systems, and if not, black water released to the environment pollutes water bodies |

Movements up the sanitation ladder have been shown to be economically viable, such as from shared toilet to private toilet, and from private pit latrine to septic tank. Hence where households are able to contribute financially to the intervention, programs should shift these populations further up the sanitation ladder.

The detailed evidence on economic performance can be used by program staff to support demand promotion campaigns, to actively participate in sanitation programs and to contribute to financing.

In many municipalities and counties of Yunnan Province, funds are adequate to deliver more sustained and quality services – that is, going beyond basic sanitation provision. These quality services better capture the full environmental and health benefits of better sanitation, and respond to the population's wish for a clean, livable environment.

Further health advancements can be achieved with improved sanitation and hygiene in Yunnan Province; hence sanitation programs should put health among their top priorities.

Insufficient financial support for sanitation programs threatens their sustainability and impact, and a financing strategy is recommended to secure funds from multiple sources.

The many agencies involved in sanitation provision suggest that efficiency gains be made from improved cross-sectoral coordination and cooperation, which will lead to improved planning and choice of technologies, strengthened mutual learning and resource saving. It is therefore advised to create a coordination mechanism to establish effective and sustainable cooperation across departments.

Users' voluntary participation in sanitation and hygiene programs is low, so people-centered implementation approaches are advised to improve participation of users and thus increase effectiveness and sustainability of selected options. Since most of the programs lack gender-sensitivity, women should be encouraged to participate in decision making and implementation as well as monitoring.

There is no systematic and comprehensive publicly-available database on the approaches, locations and coverage achieved of different sanitation and hygiene programs. Therefore to ensure a coordinated and efficient scaling up of services, it is important to set up and share an integrated database to support decision makers.

Evidence-based sanitation decision making should be promoted. Variations in economic performance of options suggest a careful consideration of site conditions is needed to select the most appropriate sanitation options and delivery approaches. Decisions should take into account not only the measurable economic costs and benefits, but also other key factors, including intangible impacts and socio-cultural issues that influence demand and behavior change, availability of suppliers and private financing, and actual household willingness and ability to pay for services.

# Foreword

In the recognition of sanitation as a key aspect of human development, target 10 of the Millennium Development Goals includes access to safe sanitation: "to reduce by half between 1990 and 2015 the proportion of people without access to improved sanitation." This reflects the fact that access to improved sanitation is a basic need: at home as well as at the workplace or school, people appreciate and value a clean, safe, private and convenient place to urinate and defecate. Good sanitation also contributes importantly to achieving other development goals such as child mortality reduction, school enrollment, nutritional status, gender equality, clean drinking water, environmental sustainability and quality of life of slum dwellers.

Despite its recognized importance, sanitation continues to lose ground to other development targets when it comes to priority setting by governments, households, the private sector and donors. This fact is hardly surprising given that sanitation remains a largely taboo subject in societies, neither is it an "attractive" subject for media or politicians to promote as a worthy cause. Furthermore, limited data exist on the tangible development benefits for decision makers to justify making sanitation a priority in government or private spending plans.

Based on this premise, the World Bank's Water and Sanitation Program (WSP) is leading the "Economics of Sanitation Initiative" (ESI) to compile existing evidence and to generate new evidence on the socio-economic aspects of sanitation. The aim of ESI is to assist decision makers at different levels to make informed choices on sanitation policies and resource allocations.

Phase 1 of the Economics of Sanitation Initiative in 2007-8 conducted and published a "sanitation impact" study, which estimated the economic and social impacts of unimproved sanitation on the populations and economies of other countries of Southeast Asia[1]. This study showed that the economic impacts of poor sanitation averaged US$22 per capita per year among five Southeast Asian countries, or 2% of annual GDP.[2] Although the country-specific economic impact as a proportion of GDP ranges from 1% in Vietnam to 7% in Cambodia, the likely impact in Yunnan Province is the regional average of 2% - which is close to the figure in Indonesia, which has similar GDP per capita and sanitation coverage levels as Yunnan Province.

The current volume reports the second major activity of ESI, which examines in greater depth the costs and benefits of specific sanitation interventions in a range of field settings in Yunnan Province in the People's Republic of China. The purpose is to provide information to decision makers on the impact of their decisions relating to sanitation – to understand the costs and benefits of improved sanitation in selected rural and urban locations, as well as to enable a better understanding of the overall national level impacts of improving sanitation coverage in China. On the cost side, decision makers and stakeholders need to understand more about the timing and size of costs (e.g. investment, operation, maintenance), as well as financial versus non-financial costs, in order to make the appropriate investment decision that increases intervention effectiveness and sustainability. On the benefit side, the monetary as well as non-monetary impacts need to be more fully understood in advocating for improved sanitation as well as making the optimal sanita-

[1] The study was not conducted in China.

[2] Hutton G, Rodriguez UE, Napitupulu L, Thang P, Kov P. Economic impacts of sanitation in Southeast Asia. World Bank, Water and Sanitation Program. 2008..

tion choice. For cost-benefit estimations, a sample of sites representing different contexts of Yunnan Province was selected to assess the efficiency of sanitation interventions, and thus illustrate the range and sizes of sanitation costs and benefits.

The ESI research is being conducted in Cambodia, China, Indonesia, Lao PDR, the Philippines and Vietnam. Similar studies are also ongoing in selected South Asian, African and Latin American countries.

While WSP has supported the development of this study, it is an "initiative" in the broadest sense, which includes the active contribution of many people and institutions (see Acknowledgment).

# Abbreviations and Acronyms

| | |
|---|---|
| ADB | Asian Development Bank |
| ALRI | Acute Lower Respiratory Infection |
| BCR | Benefit-cost ratio |
| BOD | Biochemical oxygen demand |
| CBA | Cost-benefit analysis |
| COD | Chemical oxygen demand |
| DHS | Demographic and Health Survey |
| DO | Dissolved oxygen |
| EAP | East Asia and the Pacific |
| Ecosan | Ecological sanitation |
| ESI | Economics of Sanitation Initiative |
| FAO | Food and Agriculture Organization |
| FGD | Focus Group Discussion |
| FY | Financial Year |
| GDP | Gross Domestic Product |
| GNP | Gross National Product |
| HCA | Human capital approach |
| I.E. | Income elasticity |
| IRR | Internal rate of return |
| JMP | Joint Monitoring Programme of WHO/UNICEF |
| Kg | Kilograms |

| | |
|---|---|
| MDG | Millennium Development Goals |
| Mg/l | Milligrams per liter |
| NGO | Non-governmental organization |
| NPV | Net present value |
| OECD | Organization for Economic Cooperation and Development |
| OER | Official Exchange Rate |
| PBP | Payback period |
| PEM | Protein energy malnutrition |
| SEAR-B | WHO Southeast Asia region epidemiological strata B |
| UDDT | Urine Diversion Dehydration Toilet |
| UNICEF | United Nations Children's Fund |
| USAID | United States Agency for International Development |
| VOSL | Value of a statistical life |
| WB | World Bank |
| WHO | World Health Organization |
| W&S | Water Supply and Sanitation |
| WPR-B | WHO Western-Pacific Region epidemiological strata B |
| WSP | Water and Sanitation Program |
| WTP | Willingness to pay |
| YEPD | Yunnan Environmental Protection Department |

# Glossary of Terms

**Benefit-cost ratio (BCR):** the ratio of the present value of the stream of benefits to the present value of the stream of costs. The higher the BCR is, the more efficient the intervention.

**Cost per case averted:** the discounted value of the costs for each case of a disease that is avoided because of an intervention.

**Cost per DALY averted:** the discounted value of the costs for each DALY that is avoided because of an intervention.

**Cost per death averted:** the discounted value of the costs for each death that is avoided because of an intervention.

**Cost-effectiveness ratio (CER):** the ratio of the present value of the future costs to the present value of the future health benefits in non-monetary units (cases, deaths, disability-adjusted life-years). The lower the CER the more efficient the intervention.

**Disability-Adjusted Life-Year (DALY):** a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability. One DALY can be thought of as one lost year of "healthy" life (WHO, 2010).

**Ecological sanitation (Ecosan):** a new paradigm in sanitation that recognizes human excreta and water from households not as waste but as resources that can be recovered, treated where necessary and safely used again. It is based on the systematic implementation of reuse and recycling of nutrients and water as a hygienically safe, closed-loop and holistic alternative to conventional sanitation solutions (GTZ, 2009).

**Improved sanitation:** the use of the following facilities in home compounds: flush/pour-flush to piped sewer system/septic tank/pit latrine, ventilated improved pit (VIP) latrine, pit latrine with slab, or composting toilet (JMP, 2008).

**Shared sanitation facilities:** sanitation facilities of an otherwise acceptable type shared between two or more households. Only facilities that are not shared or not public are considered improved (JMP, 2008).

**Open defecation:** the practice of disposing human feces in fields, forests, bushes, open bodies of water, beaches or other open spaces or disposed of with solid waste (JMP, 2008).

**Intangible benefits:** Benefits of improved sanitation which are difficult to quantify. These include impacts on the quality of life, comfort, security, dignity, personal and cultural preferences, among others.

**Internal rate of return (IRR):** the discount rate for which the present value of the stream of net benefits is zero. In other words, the IRR is the discount rate for which the BCR equals unit (1).

**Net benefit:** the difference between the present value of the stream of benefits to the present value of the stream of costs.

**Net present value (NPV):** the discounted value of the current and future stream of net benefits from a project.

**Payback period (PBB):** represents the number of periods (e.g. years) that are necessary to recover the costs incurred to that time point (investment plus recurrent costs).

**Unimproved sanitation:** the use of the following facilities anywhere: flush/pour flush without isolation or treatment, pit latrine without slab/open pit, bucket, hanging toilet/hanging latrine, use of a public facility or sharing any improved facility, no facilities, bush or field (open defecation) (JMP, 2008).

# Acknowledgments

The Economics of Sanitation Initiative was conducted in Cambodia, China (Yunnan Province), Indonesia, Lao PDR, the Philippines and Vietnam. The study was led by the World Bank's Water and Sanitation Program (WSP), with the contribution of WSP teams and consultants in each of the participating countries. The research team in Yunnan Province was financially and technically supported by USAID's ECO-Asia Program. The study took two years to complete, and has undergone several major peer review processes.

Guy Hutton (WSP Senior Water and Sanitation Economist and Task Team Leader) led the development of the concept and methodology for the ESI at regional level, the management and coordination of the country teams, and technical assistance. For all countries, report writing and data analysis was assisted by detailed tools and templates, and continual guidance on data input values, data interpretation and writing of reports. Björn Larsen contributed to the development of generic data collection tools and the health methodology. The study benefited from the continuous support of other WSP staff: Almud Weitz, Isabel Blackett, Yosa Yuliarsa, Irvan Tjondronegoro and WSP support staff.

In Yunnan Province, ESI has been supported by the Environmental Protection Department (EPD) of Yunnan Province. Zhou Bo led project preparation and coordination of field studies. Liang Chuan, associate professor at Yunnan Academy of Social Sciences, led and managed the research team, supervised data collection, data analysis and report writing, and played a major role in writing the study report. The research team was composed of multi-disciplinary researchers: Fang Jinmin (program approach analysis and health data collection); Dong Di and Dong Lin (cost-benefit and cost-effectiveness analysis); Luo Ronghuai (focus group discussions); associate researchers Zhang Tiwei, Zou Yahui and Wang Jing (subgroup leaders of field survey and data set management); Zhouzheng Yuxiao (team member); and Yang Liqiong and Zhang Pu from YEPD (management of water quality survey, the external environment survey and policy issues).

The research team also appreciates the assistance of doctors and health researchers from the Associated Hospital of Yunnan University in providing health data. Special thanks are also given to the graduate students from Southwest Forestry College, Yunnan Normal University and Yunnan Ethnological University, who worked hard in the field to conduct the household survey.

The contribution of peer reviews of the Yunnan report is gratefully acknowledged. Paul Kriss (World Bank, Beijing) and Linda Shi (ECO-Asia) provided valuable comments. Peer reviewers of other country reports also fed into the final version of this report, whose contribution is acknowledged in the specific country report they contributed to.

It is also acknowledged that many governmental agencies and institutes including Yunnan Provincial Development and Reform Committee, Rural Energy Station, Yunnan Provincial Health and Disease Control Center, Women's Federation, Urban Construction Bureau of Kunming Municipal City, Yunnan Provincial Forestry Department, and the Poverty Alleviation Office of Yunnan Provincial Government have all provided peer reviews to validate the research results and policy recommendations. Special thanks are given to those local community organizations and local agencies which supported the field surveys.

The ESI has been financed by WSP's regional multi-donor trust fund for East Asia funded by the Swedish International Development Agency and AusAID. The Asian Development Bank co-financed the consultant teams in Indonesia, the Philippines and Vietnam. The study in Yunnan Province was co-financed by the ECO-Asia program supported by USAID. WSP and the report authors are grateful to the funding agencies for their support.

## Reference for citation:

*Economic assessment of sanitation interventions in Yunnan Province, People's Republic of China.* Liang Chuan, Guy Hutton, Yang Liqiong, Fang Jinmin, Zhang Tiwei, Dong Lin, Zhang Pu, Luo Ronghuai. World Bank, Water and Sanitation Program. 2012.

## Other country and synthesis reports:

*Economic assessment of sanitation interventions in Cambodia.* Sam Sok Heng, Guy Hutton, Poch Kongchheng, Phyrum Kov. World Bank, Water and Sanitation Program. 2012.

*Economic assessment of sanitation interventions in Indonesia.* Asep Winara, Guy Hutton, Oktarinda, Edi Purnomo, Koderi Hadiwardoyo, Indon Merdykasari, Takdir Nurmadi, Bert Bruinsma, Dedek Gunawan, Dadang Fadilah, Martin Albrecht. World Bank, Water and Sanitation Program. 2011.

*Economic assessment of sanitation interventions in Lao People's Democratic Republic.* U-Primo Rodriguez, Guy Hutton, Alan Boatman. World Bank, Water and Sanitation Program. 2012.

*Economic assessment of sanitation interventions in the Philippines.* U-Primo Rodriguez, Guy Hutton, Nelissa Jamora, Dieldre Harder, Jeremy Ockelford and EdKarl Galing. World Bank, Water and Sanitation Program. 2011.

*Economic assessment of sanitation interventions in Vietnam.* Nguyen Viet Anh, Guy Hutton, Hoang Thuy Lan, Phan Huyen Dan, Le Thu Hoa, Bui Thi Nhung. World Bank, Water and Sanitation Program. 2012.

*Economic assessment of sanitation interventions in Southeast Asia.* Guy Hutton, U-Primo Rodriguez, Asep Winara, Nguyen Viet Anh, Sam Sok Heng, Kov Phyrum, Liang Chuan. World Bank, Water and Sanitation Program. 2012.

Full research reports as well as summary reports are available for each country, in both English and in local languages. All country reports are accessible from http://www.wsp.org

# Content

# List of Tables

# List of Figures

# List of Annex Tables

# Development Indicators for PR China and Yunnan Province

| Variables | China | Yunnan Province |
|---|---|---|
| **Population** | | |
| Total population (2008) | 1,328 million[1] | 45.4 million[9] |
| Rural population (%) | 54.3 %[1] | 76.6%[9] |
| Urban population (%) | 45.7 %[1] | 23.4%[9] |
| Annual population growth (%) (year 2008) | 0.51 %[1] | 0.63%[9] |
| Proportion of population under 14 years of age (% of total) (2008) | 19%[1] | 26%[16] |
| Under 5 mortality rate (deaths per 1000) | 24[14] | 74.9[13] |
| Female population (% of total) (2008) | 48.5%[1] | 48.0%[9] |
| Population below poverty line (%) (2006) | 3.7 %[8] | 6.4%[12] |
| **Economic** | | |
| Currency name | Renminbi Yuan (RMB) | |
| Year of cost data presented | 2009 | |
| Currency exchange with US$ (average 2009) | 6.83[2] | |
| GDP per capita (US$) (2009) | US$ 3,603[3] | US$ 2,003[1] |
| GDP per capita adjusted for purchasing power (2009) | I$ 6,000[17] | I$ 3,336 |
| **Sanitation** | | |
| Improved total (%) (2004) | 40.1 %[6] | n.a. |
| Improved rural (%) (2007) | 59.7% (2008)[6] | 51% (2006) |
| Rural with road access (2008) | 86.4%[4] | 70.5%[10] |
| Rural without road access (2008) | 13.6%[4] | 29.5%[10] |
| Improved urban (%) (2004) | 86.55 %[6] | n.a. |
| Sewerage connection (urban areas, 2008) (%) | 70.4%[5] | 30% |

Note: n.a.- not available

Sources:


[1] China population information web http://www.cpirc.org.cn/tjsj/tjsj_cy_detail.asp?id=10410
[2] http://www.pbc.gov.cn/diaochatongji/tongjishuju/gofile.asp?file=2009S08.htm
[3] http://zhidao.baidu.com/question/134290928.html
[4] Perspective on legal protection of the plight of China's rural roads. http://mcxjtj.smx.gov.cn/n42513.aspx
[5] http://hzs.ndrc.gov.cn/newhjyzyjb/t20090703_289320.htm
[6] http://wwwold.bjmu.edu.cn/extra/col19/1225161462.pdf
[7] 2008 Chinese Environment Status Report
[8] http://news.xinhuanet.com/politics/2006-10/30/content_5266164.htm
[9] http://news.yninfo.com/yn/zhxw/200902/t20090218_773538.htm
[10] http://yunnan.stis.cn/ynjj/jingctj/dfjj/200908/t20090812_264314.html
[11] http://www.yn.gov.cn/yunnan,china/74600764432973824/20090415/1189980.html
[12] http://www.china.com.cn/chinese/pinkun/956567.htm
[13] WANG Xing-tian; GUO Guang-ping; ZHOU Hong; et al. Tendency and Evaluation of the Deaths among Children under 5 Years in Yunnan from 1975 to 2005. Chinese Journal of Natural Medicine.2007,9(2). (2000 data)
[14] http://www.cnr.cn/news/200709/t20070914_504569460.html (2006 data)
[15] http://www.chinacitywater.org/rdzt/chshp/10684.shtml
[16] Yunnan Statistical Yearbook 2009. Compiled by the Statistical Bureau of Yunnan Province and Survey Office of the National Bureau of Statistics in Yunnan.2009. This statistic reflects data from the year 2000.
[17] http://www.photius.com/rankings/economy/gdp_per_capita_2009_0.html

# I. Introduction

## 1.1 RISKS OF POOR MANAGEMENT AND ISOLATION OF HUMAN EXCRETA

Poor sanitation has many negative impacts. A first phase study of the Economics of Sanitation Initiative (ESI) in five countries of Southeast Asia found that poor sanitation causes considerable financial and economic losses. Financial losses – including direct monetary costs – average 0.44% of annual GDP, while overall population welfare (i.e. economic) losses average 2% of GDP. The majority of economic losses are shared between health (54%), water resources (25%) and time spent accessing open defecation sites or public sanitation facilities (15%)[1].

Like in other developing countries, water contamination has become the greatest challenge for environmental protection and sustainable development in China. In Yunnan, the contamination of surface water bodies, including the province's major lakes and rivers, has been caused by human activities: agriculture, industry, deforestation and land reclamation, as well as household wastewater and human excreta. Poor household wastewater and excreta management – made worse by continued population growth – has become major threats to water resources protection in Yunnan Province. For example, water quality in the Dianchi Lake deteriorated from the quality of drinking water to the bottom (5th) grade of water quality, due partly to poor household wastewater and excreta management, causing eutrophication in sections of the lake. Protecting limited water resources, particularly lakes and drinking water sources, from contamination of human and animal waste is one of the priority issues for environmental agencies.

Widespread reuse of untreated human and animal excreta as agricultural fertilizer in China's rural areas is an important contributor to polluting water sources and spreads infectious diseases. A survey of rural households from 2006 to 2007 conducted by the National Patriotic Health Campaign Committee, the Ministry of Health, revealed that 84% of households use excreta in agricultural production, and most of these were using non-sanitary latrines as opposed to sanitary latrines. Hence the risk of transmitting fecal-oral diseases due to reuse of untreated manure is high[2].

## 1.2 SANITATION OPTIONS AND DEFINITIONS

Improved sanitation facilities are defined in terms of the types of technology and levels of services that are more likely to be sanitary than unimproved technologies. Having access to improved sanitation is seen as one of the basic human needs and identified as one indicator of the Millennium Development Goals. Improved sanitation includes connection to public sewers, connection to septic systems, pour-flush latrines, simple pit latrines and ventilated improved pit latrines. Not considered as improved sanitation are service or bucket latrines (where excreta is manually removed), public latrines and open latrines[3].

In China, a distinction is made between sanitary latrines and sanitary latrines with safe excreta disposal. **Sanitary latrines** are latrines with wall, roof and door, closed non-leaking storage tank, with slab, no worms, no bad odors, excreta emptied in a timely manner, and safe disposal of excreta separately, and **sanitary latrines with safe excreta disposal** are sanitary latrines that, in addition, enable reduction, re-

[1] Source: "Economic Impacts of Sanitation in Southeast Asia." Hutton G, Rodriguez UE, Napitupulu L, Thang P, Kov P. World Bank, Water and Sanitation Program. 2008.
[2] http://cn.chinagate.cn/health/2008-02/18/content_10079458.htm
[3] According to the WHO / UNICEF Joint Monitoring Programme.

moval of or killing pathogens in human excreta, therefore avoiding infections[4]. By definition, a sanitary latrine in the Chinese context is equivalent to improved sanitation accepted internationally.

Six main sanitary latrines with safe excreta disposal recommended by governmental sanitation programs include a three grid septic tank, a double-urn funnel-type lavatory, a 3-in-1 biogas digesters toilet, a urine diversion dehydration toilet (UDDT), a flush toilet to sewer, and double (alternating) pit latrine.

**The three grid septic tank** provides minimal on-site treatment for toilet wastewater through a concrete structure composed of three tandem connected chambers, where wastewater flows in, stays and gradually leaves and get cleaned via simple settlement and digestion processes.

**The double-urn funnel-type lavatory** is composed of two connected urns and a funnel-type squatting pan. The urn, which is placed directly under the pan is used for storage and settling, its overflow flows into the second urn where organic matters are decomposed and pathogens are killed over a period of time. The digested liquid is rich in nutrients and is a good fertilizer. The pan is flushed by a minimum amount of water.

**The 3-in-1 biogas digester toilet** is a structure integrated with a latrine where human and animal excreta, kitchen waste, agricultural waste are disposed of through a fermentation process and biogas is produced for household use.

**Urine-diverting dry toilets (UDDT)** do not mix urine and feces at the point of collection and do not use water for flushing. In China the function of this type of latrine is largely achieved through a reversible squatting method allowing the separation of urine and feces placed on two excreta/fecal vaults being used alternatively. Urine is channeled to a bucket or storage tank which is convenient for urine reuse. After dehydration for an appropriate period of time, the fecal matter can be applied as safe organic fertilizer to farmland.

**Flush toilets to sewer** are flush toilets connected to a sewer system and toilet wastewater is then purified in centralized or decentralized treatment facilities.

**A double (alternating) pit latrine** is a type of dehydration toilet with water flushing. Its two pits are used in shifts: while one pit is used the other one will be closed to allow excreta to dehydrate, and allow safe disposal of the excreta after six months.

Figure 1 shows that among all these six types of sanitation option, flush toilets to sewers, the three grid septic tank and 3-in-1 biogas digester toilets are the dominant technologies adopted in both Yunnan Province and China. Many factors: economic, social, cultural, climatic, and geographical, determine the type of technology to be chosen.

## 1.3 SANITATION AND HYGIENE IMPROVEMENT IN YUNNAN PROVINCE

In rural Yunnan Province the coverage of sanitary latrines has remained low, compared to the majority of the provinces and municipalities in China, despite a big leap having been achieved within the province in the last two decades. As shown in Figure 2, by the end of 2009 its sanitary latrine coverage was 54% and the share of sanitary latrines with safe excreta disposal was 27%, lower than the national average of 63.2% and 40.5% respectively, ranking 19th out of 30 provinces and municipalities of the country[5]. The diagram below illustrates the continuous sanitation development in Yunnan in the last eight years. The sharp decline of sanitation coverage and number of rural households in the diagram in 2006 is caused by changing statistical methodology.

The basic sanitation coverage of the three study areas, namely Kunming, Dai and Wenshan is shown in Table 1.

Access to sanitary latrines in rural areas of Yunnan is targeted to have reached 60% by the end of 2010, and access to sanitary latrines with safe excreta disposal is targeted to have reached 35%. While the data are not yet available to report on whether the target has been reached or not, the

[4] Technical Guidelines for Rural Latrine Improvement (provisional), NPHCC, May 2009.
[5] Health Yearbook of China 2010.

**FIGURE 1:** DISTRIBUTION OF SANITATION OPTIONS – COMPARING YUNNAN PROVINCE WITH PR CHINA, 2009

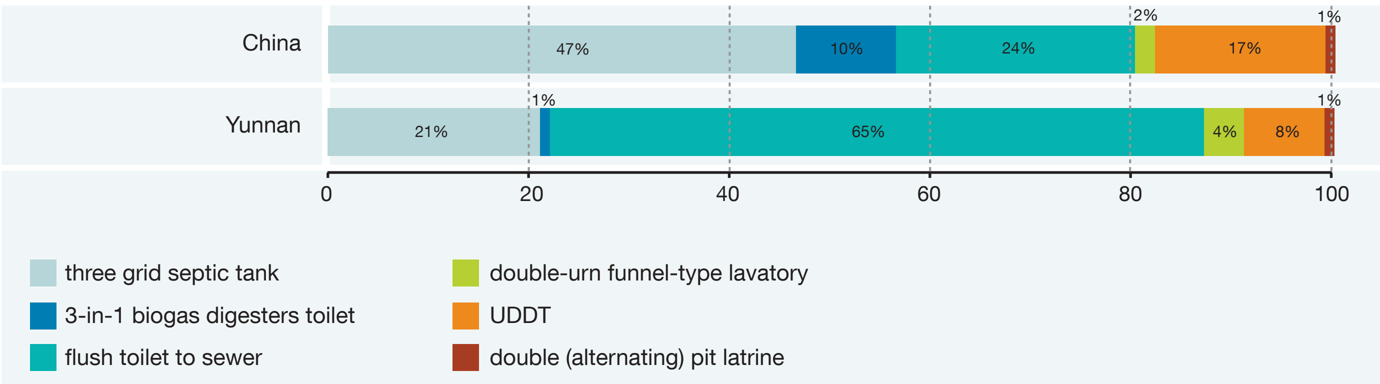



**FIGURE 2:** RURAL SANITATION PROGRESS IN YUNNAN PROVINCE, 2002 TO 2009

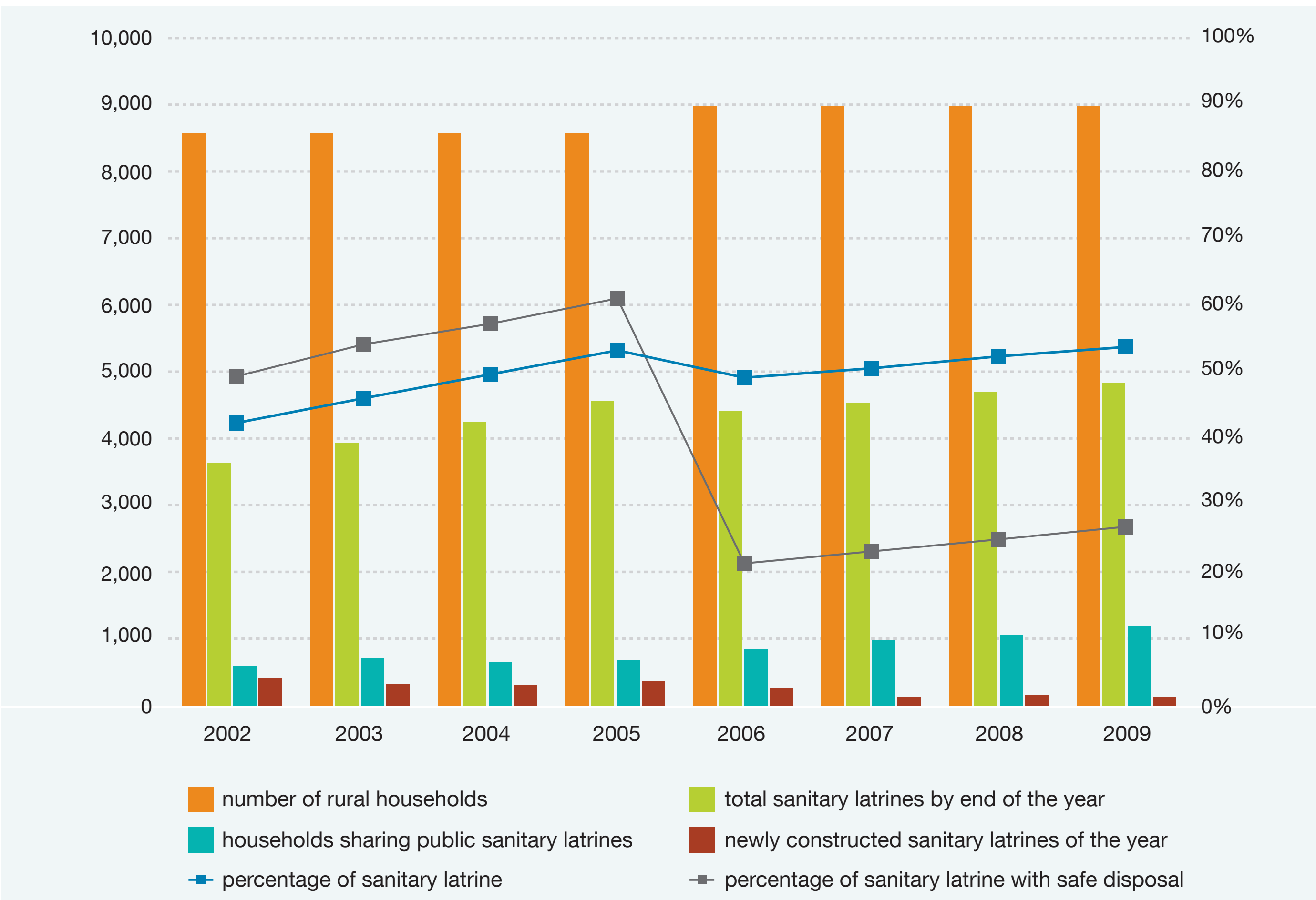



**TABLE 1:** BASIC SANITATION COVERAGE IN YUNNAN - 2008

| Locality | Coverage of sanitary latrines (%) | Coverage of sanitary latrines with safe excretal disposal (%) |
|---|---|---|
| Kunming Municipal City | 64% | 32% |
| Dali Prefecture | 50% | 27% |
| Wenshan Prefecture | 49% | 25% |
| **Yunnan Province** | **54%** | **27%** |

Source: Yunnan PHHC

development trends indicated in Figure 1 suggest the sanitation targets set out in the 11th five-year plan of Yunnan are unlikely to happen.

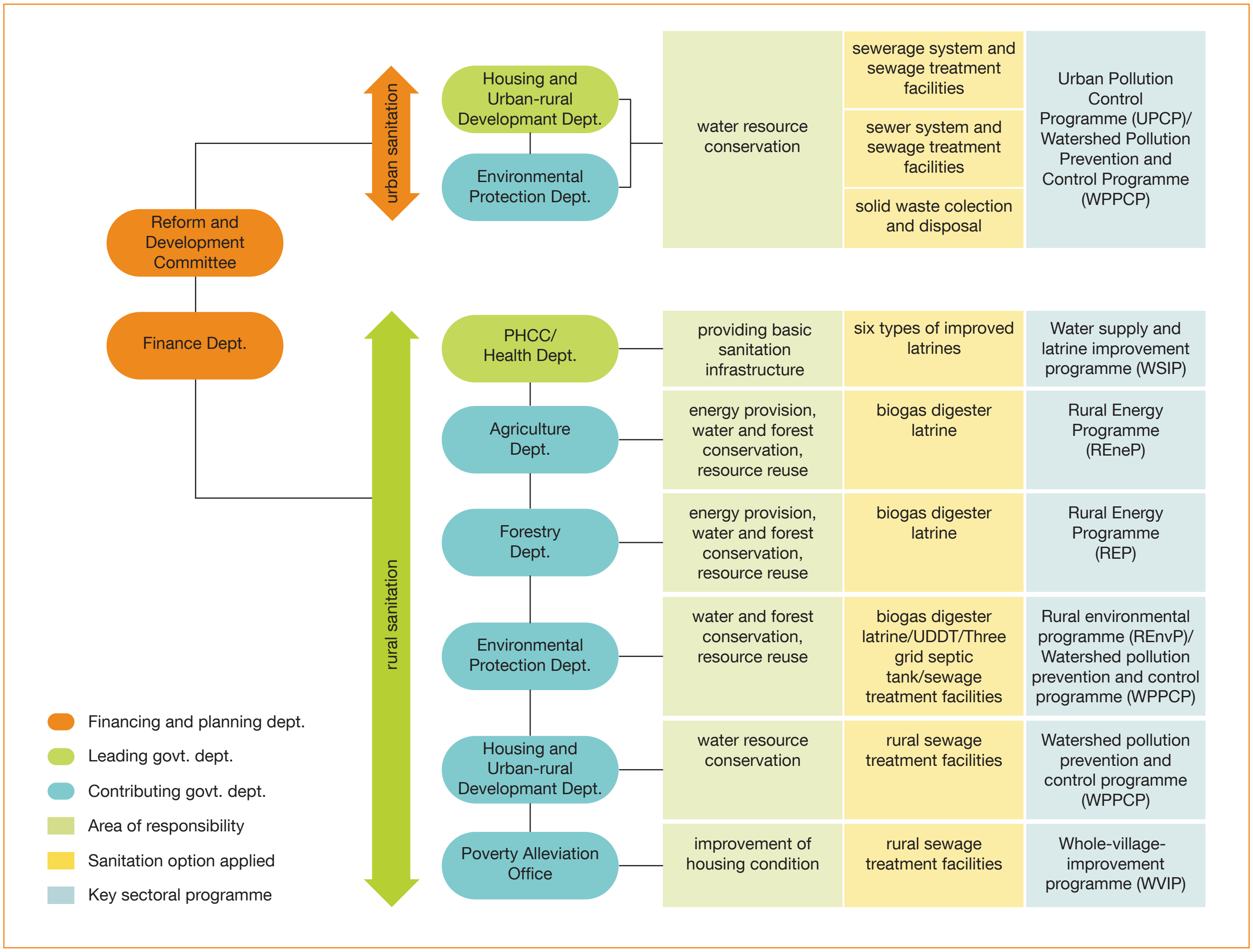
## 1.4 INSTITUTIONS AND PROGRAMS

The national government aimed to improve sanitation coverage to 65% (Eastern China), 55% (Central China) and 35% (Western China) during 2001-2010. For 2009 and 2010 it budgeted 2.86 billion RMB (US$0.43 billion) for constructing 7.58 million improved latrines with safe excreta disposal in rural China[6].

For such a huge and continuous investment program, a mechanism with multiple governmental agencies' participation for sanitation development has been in place for years, and this mechanism allows the general public including civil societies, enterprises, and individuals to contribute to full basic sanitation access in China. For urban sanitation the Ministry of Housing and Urban-Rural Development (MHURD) is taking the lead, while in rural areas the Ministry of Health (MoH) takes on a coordination and key implementation role through the National Patriotic Health Campaign Committee (NPHCC) which has other governmental agencies and institutions as its members. At provincial and lower levels the organizational structure corresponds to the national one.

Among the sectoral governmental agencies contributing to sanitation improvement, the housing and urban-rural development department and health department have a di-

**FIGURE 3:** ORGANIZATIONAL STRUCTURE AND PROGRAMS RELATED TO WATER RESOURCES, WATER SUPPLY, AND SANITATION




[6] China's Progress towards the Millennium Development Goals 2010 Report.

rect mandate to provide basic sanitation infrastructure and increase access to improved sanitation, while other departments such as agriculture, forestry and environmental protection departments contribute to sanitation improvements via their energy, security and natural resources saving. Figure 3 provides an overall picture of the governmental structure for sanitation in China.

The household biogas digesters, supported by the relevant governmental agencies in Yunnan, successfully scaled up to cover 2.5 million households by September 2010 at a steady increase of 200,000 households each year[7]. By the end of 2010, the total biogas households amounts to 3 million, accounting for 35.9% of the total rural households of the province[8].

By 2009 there were 42 centralized sewage treatment plants in place, posing a treatment capacity of 1,342,000 $m^3$/d, and achieving a domestic wastewater treatment rate of 67.1%[9]. According to the Yunnan urban sewerage treatment plan, by the year 2012, 143 centralized domestic waste water treatment projects to cover all the districts, municipalities and county seats in Yunnan (129 in total) will have been constructed. By then the urban domestic wastewater collection rate will reach 85% and treatment rate 80%[10]. The targeted treatment capacity is 90% of urban households, 70% of households in peri-urban areas, and 40% in rural areas.

Focusing on villages located around the nine key lakes in Yunnan, the Environmental Control Program for Lakeshore and Lake-adjacent Villages of Nine Plateau Lakes in Yunnan (2009-2011) addresses drinking water safety, domestic wastewater pollution, animal waste and rural industrial pollution prevention and control. The program covers 494 lakeshore and lake-adjacent villages with a total investment of 1.2 billion RMB (US$179 million), aiming to achieve 70% of domestic wastewater treatment coverage and 90% access to improved sanitation of these villages. Currently, decentralized village domestic wastewater treatment facilities using biological methods are being piloted in Lake Dianchi and Erhai watersheds, and a new household wastewater treatment facility similar to a standard septic tank but composed of five grids is being tested in villages close to Erhai lake.

Apart from the three dominant sanitation options (three grid septic latrines, biogas toilets, and toilets connected to sewer) about 93,000 UDDT units[11] were constructed mainly in Daichi watershed and some in Erhai watershed from 2002 to 2007, considering the prominent environmental benefit of this technology. Its planned roll-out however, was not carried forward further due to a generally low utilization rate. However, examples of successful use of UDDT can also be found in some localities of Yunnan.

Building on the existing 4,829,000 improved latrines that covered 53.74% of rural households, Yunnan was supposed to have achieved 56.5% access to improved sanitation in 2010, which implies that 247,000 new sanitary latrines with safe excreta disposal shall be newly built[12].

### 1.5 FUNDING MECHANISM

Upgrading the sanitation state in China needs a robust co-financing mechanism, despite a big share of the investment being provided by different levels of government. Sanitation, as one of the public services, has been continuously subsidized by the central government, provincial and lower levels of government. Funds for sanitation provided by the central to local governments vary in volume and mechanism. They can be funds exclusively for water supply and latrine improvement programs or funds for urban environmental infrastructure only. They can also be part of the funds for general uses, for instance, poverty alleviation and forest conservation. To a large extent sanitation construction plans and financing plans of different governmental departments are coordinated by the reform and development committee and the finance ministry/department. Governmental investment for the implementation of a sectoral program, such as WSIP, often comes from multiple sources. The central government requires local governments (provincial, prefectural, county, and township governments) to provide counterpart

[7] http://www.greentimes.com/green/news/yaowen/zhxw/content/2010-09/16/content_104237.htm
[8] Yunnan Rural Energy Development Plan (2003-2010).
[9] Environmental Status Report of Yunnan 2009.
[10] Construction Plan for Urban Sewage Treatment and Reuse Facilities in Yunnan (2008 to2012)
[11] Yunnan PHCC.
[12] http://www.moh.gov.cn/publicfiles/business/htmlfiles/mohjbyfkzj/s5898/200912/44928.htm.

funds for projects. Shares among tiers of government largely depend on the source/nature of subsidies and their financing capacities. Subsidies of the state government often favor less developed over more developed regions.

WSIP specific funds from the central government subsidize components such as the septic tank, bowl, and the platform (made from prefabricated board), at different rates for different regions (e.g. 400 yuan per household in the midwest, 300 yuan per household in the eastern region). Local matching funds shall be equal to the central government's funds. For central and western provinces, funds provided by the provincial government should not be less than half of the total matching fund. Meanwhile, the provincial government needs to provide a sufficient budget for technical guidance, training, health education monitoring and inspection.

For urban wastewater treatment plants, the Development and Reform Commission, MEP and MHURD jointly co-finance the initial capital for wastewater treatment plants, with a maximum co-financing of 70% of capital costs, and the provincial government is expected to finance the rest of the initial capital outlay.

To upgrade urban sanitation, the central government provides exclusive funds and general subsidies. Urban wastewater treatment projects listed in the national 11th five-year plan for urban sewage treatment and reuse of infrastructure construction receive a subsidy in the form of a reward fund at 40 RMB/$m^3$ of treatment capacity and 200 RMB/m of a sewage pipe system. In Yunnan, besides the abovementioned funding opportunities from the national government, the provincial financial budget will allocate 0.4 billion RMB (US$149 million) for urban sewage treatment projects each year from 2008 to 2012[13]. The operation and maintenance costs are to be recovered by a wastewater discharge fee at a price of 1.0 yuan per cubic meter.

When UDDTs were constructed in Dianchi catchment, construction costs of some of the units were fully covered by the Kunming municipal government and for some units households contributed 100 to 180 yuan. A subsidy from the central government for biogas digester latrines is 1,000 yuan/unit and in Yunnan another 1,000 yuan is added on by the provincial government. The rest is shared by governments and households at lower levels.

In addition to government financing, village communities and individuals are required to bear part of the construction costs where their contribution can be either in kind or cash. Local societies, organizations and individuals are encouraged to shoulder part of the financial burden as well. For urban sanitation infrastructure, even more diversified financing sources and mechanisms exist.

## 1.6 SCALING UP SANITATION IN CHINA AND THE MILLENNIUM DEVELOPMENT GOALS

The Chinese government puts the improvement of sanitation facilities and scaling up of sanitary latrines as one of the top priorities for water conservation and improvement of sanitary conditions and health. During the early 1990s, China began a long-term and sustained scaling up of sanitary latrines, providing both policy support and technical assistance for implementation of programs. Significant progress in China towards the realization of the Millennium Development Goal (MDG) Target 7 has been made, which seeks to reduce by half the proportion of the population without sustained access to basic sanitation. Statistics of the Joint Monitoring Programme (JMP) evaluation report from the United Nations Children's Fund and World Health Organization indicated that in both rural and urban areas, sanitation coverage in China is increasing, but the average rate in rural areas is far behind that in urban areas (see Figure 4). By the end of 2009, China had reached 63.2% coverage of improved latrines and 40.5% of improved latrines with safe excreta disposal[14]. JMP estimates show coverage of improved sanitation in urban areas of 74% and rural areas of 56%. Based on progress since 1990, projections of sanitation coverage to 2015 suggest that the MDG sanitation target will be achieved in China.

However, sanitation improvement in China still faces big challenges. First, the urban-rural disparity in terms of access to improved sanitation remains large; and the gap between western and eastern parts of China is unlikely to be closed

[13] Construction Plan for Urban Sewage Treatment and Reuse Facilities in Yunnan (2008-2012).
[14] Health Yearbook of China 2010.

**FIGURE 4:** USE OF IMPROVED SANITATION FACILITIES IN CHINA, ACCORDING TO THE JOINT MONITORING PROGRAMME (LATEST DATA 2010)


Estimated coverage 2012 update

| Year | Improved | Shared | Unimproved | Open defecation |
|---|---|---|---|---|
| 1990 | 48% | 15% | 34% | 3% |
| 1995 | 54% | 18% | 26% | 2% |
| 2000 | 61% | 20% | 18% | 1% |
| 2005 | 68% | 22% | 9% | 1% |
| 2010 | 74% | 24% | 2% | 0% |

Estimated coverage 2012 update

| Year | Improved | Shared | Unimproved | Open defecation |
|---|---|---|---|---|
| 1990 | 15% | 4% | 72% | 9% |
| 1995 | 25% | 6% | 62% | 7% |
| 2000 | 35% | 9% | 51% | 5% |
| 2005 | 46% | 11% | 40% | 3% |
| 2010 | 56% | 14% | 28% | 2% |

Shared facilities : The proportion of the population using a shared improved sanitation facility is based on the CEN91and SAGE08

anytime soon. Areas with low access coverage normally are remote and less economically developed provinces. Financial constraints do not give them much chance to inject sufficient funds into sanitation, and sanitation investment has to rely mainly on central government support. In many cases, even local financing cannot meet the counterpart fund requirements.

In most places in China insufficient budgets for laying corresponding sewer pipes also caused the sewage treatment plants to operate at under-capacity. A survey report of MEP revealed that among 1,178 sewage plants which have been in operation longer than one year, 32% of them are operated at less than 60% of designed load and 7% of them run at lower than 30% of designed load[15].

[15] http://news.163.com/09/0702/08/5D73OJVC000125LI.html.

## 1.7 ESI STUDY AND STRUCTURE OF THE REPORT

The present study is part of a second phase of the Economics of Sanitation Initiative. This is the first study in China that conducts a comprehensive economic assessment in a range of geographical locations – rural, peri-urban and urban areas – and comparing several different sanitation options per field site.

This report contains a further eight chapters, as follows. Chapter 2 presents the study aims, objectives and research questions. Chapter 3 introduces the research methodology and data sources. Chapter 4 presents the results on the benefits of improved sanitation options, including health, water source access and treatment, access time, reuse of excreta, intangible preferences and the external environment. Chapter 5 presents the costs of improved sanitation in the field sites, including the total investment and recurrent costs per sanitation option, broken down by financial and economic costs, and the marginal costs of moving up the sanitation ladder. Chapter 6 compares sanitation program performance in the field sites using simple performance indicators, and cites examples of program design that enhance performance from selected programs. Chapter 7 presents the cost-benefit analysis, comparing efficiency indicators for ideal and actual performance of sanitation programs, including the marginal efficiencies of moving up the sanitation ladder. Chapter 8 discusses the results in the light of the main findings, the current and future sanitation policies, and the research methodologies of the study. Chapter 9 proposes policy recommendations to the relevant governmental agencies and sector stakeholders for improved sanitation decision making.

# II. Study Aims

## 2.1 OVERALL PURPOSE

The purpose of the Economics of Sanitation Initiative (ESI) is to promote evidence-based decision making using improved methodologies and data sets, thus increasing the effectiveness and sustainability of public and private sanitation spending.

Better decision making techniques and economic evidence themselves are also expected to stimulate additional spending on sanitation to meet and surpass national coverage targets.

## 2.2 STUDY AIMS

The aim of this current study is to generate robust evidence on the costs and benefits of sanitation improvements in different programmatic and geographic contexts in China, leading to the selection of the most efficient and sustainable sanitation interventions and programs. Basic hygiene aspects are also included, insofar as they affect health outcomes.

The range of evidence is presented in a few selected efficiency indicators and distilled into key recommendations to increase uptake by a range of sanitation financiers and implementers, including different levels of government and sanitation sector partners, as well as households and the private sector.

Standard outputs of cost-benefit analysis include benefit-cost ratios, internal rate of return, payback period, and net benefits (see Glossary). Cost-effectiveness measures relevant to health impacts will provide information on the costs of achieving health improvements. In addition, intangible aspects of sanitation not quantified in monetary units are highlighted as being crucial to the optimal choice of sanitation interventions.

This study also contributes to the debate on approaches to sanitation financing and ways of scaling up sanitation improvements to meet national targets.

## 2.3 SPECIFIC STUDY USES

By providing hard evidence on the costs and benefits of improved sanitation, the study will:

- Provide **advocacy material** for increased spending on sanitation, and to prompt greater attention of sector stakeholders to efficient implementation and scaling up of improved sanitation.
- Enable the inclusion of **efficiency criteria** in the selection of sanitation options in government and donor strategic planning documents, and in specific sanitation projects and programs.
- Bring greater focus on **appropriate technology** through increased understanding of the marginal costs and benefits of moving up the "sanitation ladder" in different geophysical, socio-economic and demographic contexts.
- Provide the empirical basis for improved estimates of the total costs and benefits of **meeting sanitation targets** (e.g. MDG or other national target), and contribute to provincial and national strategic plans for meeting and surpassing these targets.
- Contribute to the design of **feasible financing options** through identification of the beneficiaries as well as cost incidence of sanitation programs.

## 2.4 RESEARCH QUESTIONS

In order to fulfill the overall purpose of the study, research questions were defined that have direct bearing on sanitation policies and decisions, distinguished for overall efficiency questions (i.e. cost versus benefit), and for costs and benefits separately[16].

[16] "Costs" and "benefits" refer simultaneously to financial and economic costs, unless otherwise specified.

The major concern in economic evaluation is to understand economic and/or financial efficiency – in terms of return on investment and recurrent expenditure. Hence the focus of economic evaluation is on what it costs to deliver an intervention and what the returns are. Several different efficiency measures allow examination of the question from different angles, such as number of times by which benefits exceed costs, the annual equivalent returns, and the time to repay costs and start generating net benefits (see Box 1). Also, as sanitation and hygiene improvement also fall within the health domain, economic arguments can be made for investment in sanitation and hygiene interventions with the health budget, if the health return per unit cost invested is competitive compared with other uses of the same health budget.

As well as overall efficiency questions, it is useful from decision making, planning and advocacy perspectives to better understand the nature and timing of costs and benefits, as well as how non-economic aspects (such as socio-cultural considerations) affect the implementation of sanitation interventions (see boxes 2 and 3). Furthermore, given that several impacts of improved sanitation cannot easily be quantified in monetary terms, this study attempts to give greater emphasis to these "intangible" impacts in the overall cost-benefit assessment.

**BOX 1.** RESEARCH QUESTIONS ON SANITATION EFFICIENCY

i. Are benefits greater than the costs of sanitation interventions? By what proportion do benefits exceed costs (benefit-cost ratio – BCR)?
ii. What is the annual internal rate of return (IRR)? How does the IRR compare to national or international standards for investments of public and private funds? How does the IRR compare to other non-sanitation development interventions?
iii. How long does it take for a household to recover its initial investment costs, at different levels of cost sharing (payback period – PBP)?
iv. What is the net gain of each sanitation intervention (net present value – NPV)? What is the potential interest of sanitation for business opportunities ?
v. What is the cost of achieving standard health gains such as averted death, cases and disability-adjusted life-year (DALY)?
vi. How does economic performance vary across sanitation options, program approaches, locations, and countries? What factors explain performance?

**BOX 2.** RESEARCH QUESTIONS ON SANITATION COSTS

i. What is the range of costs for each technology option in different field settings? What factors determine cost levels (e.g. quality, duration of hardware and software services)?
ii. What proportion of costs are capital, program and recurrent costs, for different interventions? What are necessary maintenance and repair interventions, and costs, to extend the life of hardware and increase sustainability?
iii. What proportion of total (economic) cost is financial in nature? How are financial and economic costs financed in each field location?
iv. What are the incremental costs of moving from one sanitation improvement to another - i.e. up the sanitation ladder – for specified populations to meet sanitation targets?

In addition, other research questions are crucial to an appropriate interpretation and use of information on sanitation costs and benefits. Most importantly, the full benefits of a sanitation intervention may not be received due to implementation issues that affect the uptake and compliance with the intervention. These factors need to be better understood to advise future program design. Also, the ESI study touches on many financing issues, related to who is paying for the interventions and who is benefiting from the interventions (and who thus may be willing to pay). Given that scale-up cannot be achieved with full subsidization of sanitation interventions by government or other sector partners, it will be key to better understanding how public money and subsidies can be used to leverage further investments from the private sector and from households themselves (see Box 4).

**BOX 3. RESEARCH QUESTIONS ON SANITATION BENEFITS**

i. What local evidence exists for the links between sanitation and the following impacts: health impact, water quality and water users, land use, time use, and welfare?

ii. What are the size of financial and economic benefits related to health expenditure, health-related productivity and premature mortality; household water uses; time savings; property value; and other welfare impacts?

iii. What proportion of the benefits are pecuniary benefits (financial gains) and what proportion are non-pecuniary benefits?

iv. What proportion of each benefit accrues to households who invest in sanitation and what proportion is external to the household?

v. What is the actual or likely willingness to pay of households and other agencies for improved sanitation?

vi. How do benefits accrue or vary over time?

vii. How is improved sanitation – and the related costs and benefits – tangibly linked with poverty reduction?

viii. What is the overall household and community demand (expressed and latent demand) for improved sanitation?

**BOX 4. OTHER RESEARCH QUESTIONS**

i. How do program design and program implementation affect costs and benefits? In practice, (how) can sanitation programs be delivered more efficiently – i.e. reducing costs without reducing benefits?

ii. How to leverage grants to incentivize investments in sanitation?

iii. What factors determine program performance? What are the key factors of success and constraint, covering contextual, institutional, financial, social and technical aspects?

iv. Which program approaches are best suited to which technical options?

v. What is the acceptability of different sanitation options and program approaches?

vi. What other issues determine intervention choice and program design in relation to local constraints: energy use, water use, polluting substance discharge, and option robustness/durability/maintenance requirements?

vii. Based on research findings, what other key issues enter into sanitation option decisions?

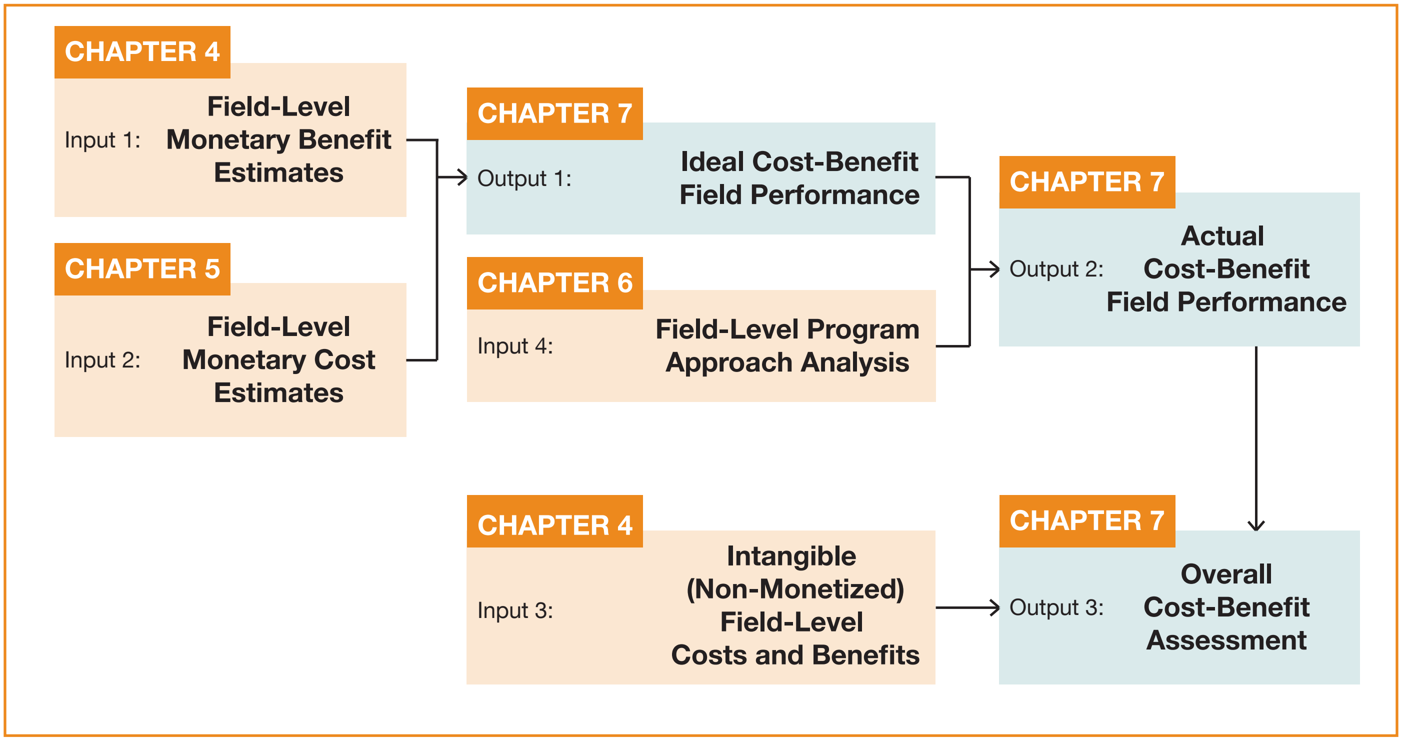
# III. Methods

The study methodology in Yunnan follows the same standard methodology developed at the regional level reflecting established cost-benefit techniques, which have been adapted to the specific sanitation interventions and research needs in Yunnan. As shown in Figure 5, the study comprises field research on the quantitative cost-benefit estimates, as well as an in-depth study of the qualitative aspects of sanitation. Two types of field-level cost-benefit performance are presented: Output 1 reflects **ideal performance** assuming the intervention is delivered, maintained and used appropriately, and Output 2 reflects **actual performance** based on observed levels of intervention effectiveness in the field sites. However, both these analyses are partial, given that the study excludes intangible benefits of sanitation improvements as well as other benefits that may accrue outside the sanitation improvement site. Hence Output 3, overall cost-benefit assessment, takes these into account.

## 3.1 TECHNICAL SANITATION INTERVENTIONS EVALUATED

The type of sanitation evaluated in this study is *household human excreta management*. Interventions to improve human excreta management in households focus on both on-site and off-site sanitation options. One of the key aims of this study, where possible, is to compare the relative efficiency of different sanitation technologies. Basic hygiene aspects of sanitation are also included, insofar as they affect health outcomes and intangible aspects.

**FIGURE 5:** FLOW OF DATA COLLECTED (INPUTS) AND EVENTUAL COST-BENEFIT ASSESSMENTS (OUTPUTS)



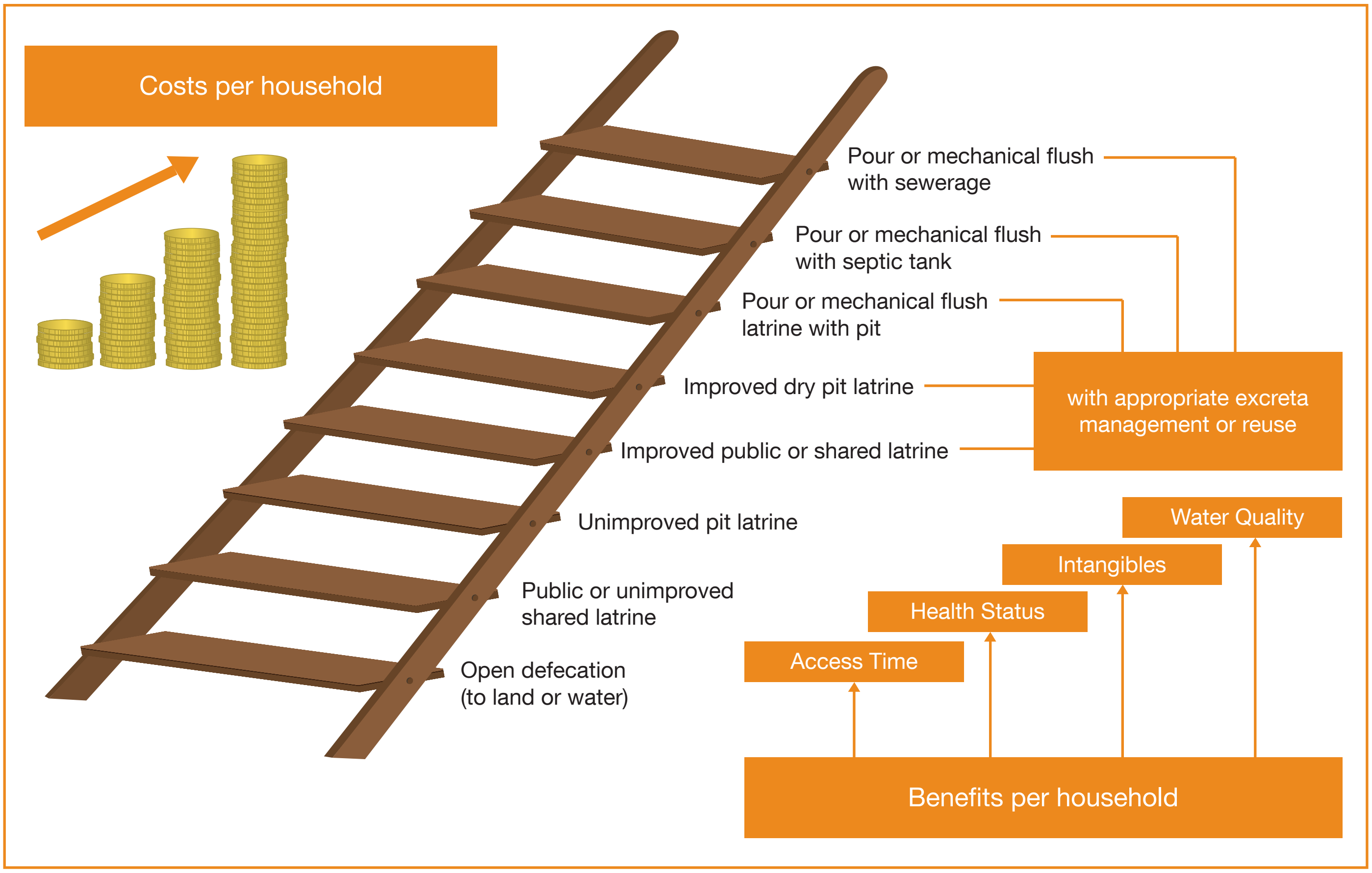
As well as human excreta management, interventions are considered that jointly address human waste with domestic wastewater management (especially in urban areas) and with animal waste management (in the case of biogas generation).

To qualify as an economic evaluation study, a cost-benefit analysis compares at least two alternative intervention options. It usually includes comparison with the baseline of "do nothing." However, comparing two sanitation options will rarely be enough: ideally the analysis should compare all sanitation options that are feasible for each setting – in terms of affordable, technically feasible, and culturally acceptable options – so that a clear policy recommendation can be made based on efficiency of a range of sanitation options, among other factors.

Technical sanitation options include all those interventions that move households up the sanitation ladder and thus bring benefits. Figure 6 presents a generalized sanitation ladder. The upward slope of the ladder reflects the assumption of greater benefits as you climb the ladder, but (generally) with higher costs. The progression shown in Figure 6 is not necessarily true in all settings and hence needs to be altered based on setting-specific features (e.g. rural or urban, different physical/climatic environments such as soil type or water scarcity).

While the study proposes to conduct analyses of the costs and benefits of achieving the MDG targets and beyond, sanitation options will not be restricted by "unimproved" and "improved" sanitation as defined by the WHO/UNICEF JMP. For example, some households will be interested in upgrading from one type of improved sanitation to another type, such as from pit latrine to septic tank, or from septic tank to sewerage. Other households are faced with a decision whether to replace a facility that has reached the end of its useful life.

**FIGURE 6:** REPRESENTATION OF THE SANITATION "LADDER"




Cautionary note: versions and interpretations of the sanitation ladder vary. This Figure is for illustrative purposes only.

Based on the ladder in Figure 6 as a starting point, Table 2 shows different types of intervention (sub-category) within the more broadly defined sanitation options. This classification provides an overview to allow a framework for interpretation of the specific options evaluated in the field settings (shown in 3.2.2), given that option sub-categories may have different associated costs and benefits.

**TABLE 2:** CLASSIFICATION OF SANITATION OPTIONS AND SUB-OPTIONS

| | Categories (JMP definition) | | Sub-categories |
|---|---|---|---|
| 0 | Open defecation | 0.1 | On plot or on land/in water outside plot |
| | | 0.2 | On plot |
| | | 0.3 | On land outside plot |
| | | 0.4 | Next to or directly in waterway/body |
| 1 | Shared/community/public latrine, unimproved | 1.1 | Public toilet (with community) |
| | | 1.2 | Shared toilet (with limited no. of other households) |
| 2 | Private latrine, unimproved | | |
| 3 | Shared/community/public latrine, improved | 3.1 | Public toilet (with community) |
| 5 | Private dry latrine, improved | 5.1 | Simple dry pit |
| | | 5.2 | Ventilated improved pit latrine (VIP) |
| | | 5.3 | Single vault composting toilet (UDDT) |
| | | 5.4 | 2-3 vault composting toilet (UDDT) |
| 6 | Private wet latrine, improved | 6.1 | Pour-flush toilet + non-watertight pit and/or dumping of sludge and/or flow directly to waterway/body |
| | | 6.2 | Sealed pit with sludge removal & septage treatment facility |
| | | 6.3 | Biogas digester (human, animal) |
| | | 6.4 | Wastewater reuse (garden, domestic) |
| 7 | Private toilet, septic tank | 7.1 | Non-watertight septic tank and/or dumping of sludge and/or flow directly to waterway/body |
| | | 7.2 | Improved septic tank with sludge removal & septage treatment facility |
| | | 7.3 | Improved septic tank with sludge removal & sludge drying bed & constructed wetland |
| | | 7.4 | Improved septic tank with safe sludge use in agriculture or fish feeding |
| 8 | Private toilet, separate sewerage[1] | 8.1 | Decentralized conventional treatment[2] |
| | | 8.2 | Decentralized natural treatment |
| | | 8.3 | Centralized conventional treatment[2] |
| | | 8.4 | Centralized natural treatment |
| | | 8.5 | Combined conventional and natural[2] |
| 9 | Private toilet, combined sewerage[1] | 9.1 | Decentralized conventional treatment[2] |
| | | 9.2 | Decentralized natural treatment |
| | | 9.3 | Centralized conventional treatment[2] |
| | | 9.4 | Centralized natural treatment |
| | | 9.5 | Combined conventional and natural[2] |

[1] Can be simplified or normal sewerage
[2] Includes primary, secondary and tertiary treatment options

## 3.2 COSTS AND BENEFITS EVALUATED

Sanitation costs are the denominator in the calculation to estimate the cost-benefit ratio and the numerator in the estimation of cost-effectiveness ratio. Thus costs are crucial to the evaluation of sanitation option efficiency. Summary cost measures include the total annual and lifetime costs, cost per household and cost per capita. For financing and planning purposes, this study disaggregates costs for each sanitation option by capital, program and recurrent costs; by financial and economic costs; by financier; and by wealth quintile. The incremental costs of moving up the sanitation ladder are assessed.

To maximize the usefulness of economic analysis for diverse audiences, the benefits of improved sanitation and hygiene are divided into three categories:

1. **Household direct benefits:** these are enjoyed by the households who are making the sanitation improvement. These actual or perceived benefits will drive the decision by the household to invest in sanitation, and will also guide the type of sanitation improvement chosen. These benefits may include: health impacts related to household sanitation and hygiene, local water resource impacts, access time, intangible impacts, house prices, and the value of human excreta reuse.
2. **Local level external benefits:** these are potentially incurred by all households living in the environment where households improve their sanitation. However, some of these benefits may not be substantial until a critical mass of households has improved their sanitation. These benefits may include: health impacts related to environmental exposure to pathogens (e.g. water sources, open defecation practices on land), aesthetics of environmental quality, and usability of local water sources for productive activities. Given the challenges in designing studies to distinguish these benefits from household direct benefits (in point 1.) this study groups local level external benefits together with household direct benefits.
3. **Wider scale external benefits:** these result from improved sanitation at the macro-level. Benefits may include: water quality for productive uses, tourism, local business impact, and foreign direct investment. They can either be linked to coverage in specific areas or zones (e.g. tourist area or industrial zone), or the country generally (e.g. investment climate). As well as improved management of human excreta, other contributors to environmental improvement such as solid waste management and wastewater treatment need to be considered. While tourism and business surveys were conducted in other ESI countries in Southeast Asia, these surveys were not within the scope of the ESI study in Yunnan Province.

Table 3 shows the impacts included in the current study, distinguishing between those impacts that are expressed in monetary units and those that are expressed in non-monetary units.

**TABLE 3:** BENEFITS OF IMPROVED SANITATION INCLUDED IN THIS STUDY

| Impact | Socio-economic impacts evaluated in | |
|---|---|---|
| | Monetary terms ($ values) | Non-monetary terms (non-$) |
| Health | • Health care costs<br>• Health-related productivity<br>• Premature death | • Disease and mortality rates<br>• Quality of life impacts<br>• Gender impacts |
| Domestic water | • Water sourcing<br>• Household treatment | • Link poor sanitation, water quality and water treatment practices |
| Other welfare | • Time use | • Convenience, comfort, privacy, status, security, gender issues |
| Environmental quality | | • Aesthetics of household and community environment |
| Output reuse | • Fertilizer or biogas generated | • Preferences for UDDT and biogas, and handling/reusing human excreta |

Key: UDDT – Urine Diversion Dehydration Toilet

While the focus of this study is on household sanitation, the importance of **institutional sanitation** also needs to be highlighted. For example, improved school sanitation affects decisions for children (especially girls) to start or stay in school until the end of the secondary level, and workplace sanitation affects decisions of the workforce (especially women) to take or continue work with a particular employer. These benefits are incremental over and above the three cited above. However, these impacts are outside the scope of this present study.

The next sections describe the study methods for the three major study components: the field level cost-benefit assessment (3.3), and the assessment of program effectiveness (3.4). Section 3.5 describes process aspects of the research such as study steering and collaboration.

## 3.3 FIELD STUDIES

### 3.3.1 FIELD SITE SELECTION AND DESCRIPTION

According to good economic evaluation practice, interventions evaluated should reflect the options faced by households, communities and policy makers. Therefore, locations should be selected that contain a range of sanitation options which are typically available in Yunnan Province, covering both urban and rural sites. By sampling a range of representative locations, the study results can be generalized outside the study settings, and hence be more useful for national, provincial and local level planning purposes.

The principal criterion for site selection applied in this study is that there has been a sanitation project or program implemented in the past five years, and at some level of scale that allows minimum sample sizes of 30 households to be collected per sanitation option per site. Once this list of projects and programs has been established, a further set of criteria was applied in order to reduce the short-list to eight locations or projects (based on the available budget). These criteria include (i) logistical feasibility for research to be conducted; (ii) potential for collaboration with project/program; (iii) being representative of Yunnan in terms of geophysical, climatic, demographic and socio-economic characteristics. Annex Table A1 shows the long list of projects, and how they perform in relation to the three criteria. The final eight sites selected are presented below. Table 4 shows the sanitation coverage in the selected field sites compared with the national coverage.

**Site 1 (R1): The villages in Luquan County** in the greater Kunming metropolitan area are located in a cool mountainous area near Yunlong reservoir, the drinking water source for Kunming. For protection of the reservoir, UDDTs and biogas are being heavily promoted by the government. Yi and Miao are the dominant ethnic groups. Four villages were sampled for the ESI survey, each with around 200 to 500 residents. These are poverty-stricken areas with an average annual income of around 1,632 yuan (US$240) per capita, and the sanitation coverage is around 30%.

**Site 2 (R2): Dali Shangguan** is a rural site on a lakeside plain. Septic tanks, UDDTs and biogas are being heavily promoted by the government. Bai is the dominant ethnic group, and the area has a total population of around 10,000 residents with an average annual income of 3,480 yuan (US$510) per capita. Sanitation coverage is around 45%.

**Site 3 (R3): The villages in Qiubei County** are located in mountainous areas or by the lake, which are often flooded in the rainy season. Zhuang, Miao and Yi are the dominant ethnic groups in these villages, which have around 200 to 500 residents each, with an average annual income of less than 1,500 yuan (US$220) per capita. The sanitation coverage is 46%, and four villages were sampled for the ESI survey. Unimproved shared and pit latrines are widely used in rural areas together with improved sanitation options such as biogas units, septic tanks, and UDDT. Open defecation in mountainous rural areas is still being practiced.

**Site 4 (U1): Kunming City** is the provincial capital of Yunnan Province located in the center of the province. It is characterized by a low altitude upland monsoon climate with scarce water resources. The total population is 3.2 million urban residents with permanent registration and 6.08 million including rural residents. Han is the dominant ethnic group. The annual income per capita is 16,495 yuan (US$2,420), and sanitation coverage is estimated at 87%

[17] Data source: local statistics and Yunnan provincial sanitation survey results.

for urban areas and 60% for the overall rural[17], peri-urban and urban areas . Public and private flush toilets with septic tanks and sewerage are the main sanitation options in the city.

**Site 5 (U2): Dali City** is a prefectural capital, located on the bank of Erhai Lake, west of Yunnan Province. It is characterized by a mountanious monsoon climate. Bai is the dominant ethnic group in the city, which has 610,000 urban residents with an annual income of 14,100 yuan (US$2,070) per capita. Sanitation coverage in urban areas is proximately 60%, and 45% for Dali prefecture including rural and peri-urban populations. Public and private flush toilets with septic tanks and sewerage are the main sanitation options in the city.

**Site 6 (U3): Qiubei City**, a county capital, is located in the karst region by Puzhehe Lake in southern Yunnan Province. It is characterized by a mountanious monsoon climate with flooding during the rainy season. Zhuang, Yi and Miao are the dominant ethnic groups in the city, which has a total population of less than 100,000. The average annual income is less than 3,500 yuan (US$515) per capita, and sanitation coverage is 46%. Public and private flush toilets with septic tanks and pit latrines are the main sanitation options in the city.

**TABLE 4:** BACKGROUND INFORMATION ON THE EIGHT SELECTED FIELD SITES IN YUNNAN PROVINCE

| Variable | Kunming Rural Villages in Luquan County (Yizi,Huoqi, Lianhe and Puzhong) | Dali Rural Xinyi and Dayingcun Administrative Villages, Shangguan Town | Qiubei Rural Villages: Puzehei Administrative, Xianrendong, Xialeshao, and Xiangshui. | Kunming Urban (Kunming City) | Dali Urban (Dali City) | Qiubei Urban (Qiubei Town) | Kunming Peri-urban (Jinning) | Peri-urban Zhoucheng, Xizhou |
|---|---|---|---|---|---|---|---|---|
| **Label** | **R1** | **R2** | **R3** | **U1** | **U2** | **U3** | **PU1** | **PU2** |
| Location & setting | Mountainous, Miao and Yi ethnic groups, upstream rural area | Lakeshore, rural area, Bai ethnic groups | Lakeshore, rural area, shallow ground water Zhuang, Maio and Yi ethnic groups | Provincial capital – densely populated city | Prefectural city, densely populated Tourism attraction Bai ethnic group | Country town, less densely populated | Small town Han, urbanizing town | Urbanizing rural area, Bai ethnic group, by Erhai lakeside |
| Baseline options (pre-program) | OD, shared or private pit latrine | Shared or private pit latrine | OD, Shared or private pit latrine | Public wet or dry latrine | Public dry latrine, pit latrine | Pit latrine | Pit latrine, shared pit latrine | Public dry pit, private pit latrine |
| Improved options (program intervention) | UDDT, biogas | Septic tank, biogas, UDDT | UDDT, biogas, wet pit latrine | Private flush toilet with septic tank to sewerage | Public flush toilet, private flush toilet with septic tank to sewerage | Flush toilet to septic tank | Public dry latrine, septic tank, UDDT | Wet latrine, septic tank |
| Average household size | | 4 | 4 | 3 | 4 | 4 | 4 | 4 |
| PROJECT INFORMATION | | | | | | | | |
| Start-end date | 2005-2008 | 2005-2008 | 2004-2008 | 1995-2000 | 2000-2004 | 2002-2007 | 2006-2007 | 2005-2008 |
| Financing agent | Yunnan Forestry Department | Yunnan EPD | German Embassy | Kunming Municipal Government | Dali Tourism Administration Office | Qiubei County Government. | Kunming Municipal Government | Dali Tourism Administration Office |
| Implementing agent | Yunlong Township Government & Energy Extension Station | Erhai Lake Management Institute | YEDI & Qiubei EPB | Urban Construction Bureau | Urban Construction Bureau | Qiubei Construction Bureau | Kunming EPB, Township Government | Erhai Nature Reserve Management Station |
| Start of project improved sanitation coverage (%) | 21.8% | 72.3% | 69.1% | 78.2% | 66.7% | 74.1% | 74.3% | 85.2% |
| End of project improved sanitation coverage (%) | 94.0% | 75.1% | 94.5% | 83.0% | 81.5% | 77.8% | 78.5% | 82.5% |

Key: EPD – Environmental Protection Department; YEDI – Yunnan Environment Development Institute; OD - open defecation
Data source: local statistics and project documents.

**Site 7 (PU1): Kunyang Town of Jinning County**, located in the greater Kunming metropolitan area, is a small town on the southern bank of Dianchi Lake. It has a monsoon climate. Han is the dominant population group, and the total population is less than 50,000 residents with an average annual income of around 9,000 yuan (US$1,320) per capita. Sanitation coverage is estimated at around 60%. Public dry latrines, septic tanks, and UDDT are all used in this peri-urban area.

**Site 8 (PU2): Dali Zhoucheng** is an urbanizing rural area near Dali City. It is located by Erhai Lake, with Bai as the dominant ethnic group. The total population is around 10,000 residents with an average annual income of 5,135 yuan (US$750) per capita, and sanitation coverage is around 45%. Public dry toilets, pit latrines, shared, UDDT, and septic tanks are all used in this peri-urban area.

### 3.3.3 COST ESTIMATION METHODOLOGY

This study estimates comprehensive costs of different sanitation options, including program management costs as well as on-site and off-site costs. Cost estimation was based on information from three data sources (sanitation program or project documents, the provider or supplier of sanitation services, and the ESI household questionnaire, described in 3.3.4). Data from these three sources were compiled, compared, adjusted, and entered into standardized cost tabulation sheets. Annual equivalent costs of different sanitation options were calculated based on an annualized investment cost (taking into account the estimated length of life of hardware and software components) and adding annual maintenance and operational costs. For data analysis and interpretation, financial costs were distinguished from non-financial costs, and costs were broken down by financiers. Information from documents of sanitation projects and providers as well as market prices was supplemented with interviews with key resource people to ensure correctness of interpretation, and to enable adjustment where necessary.

### 3.3.4 BENEFIT ESTIMATION METHODOLOGY

To be credible to decision makers, economic evaluation of sanitation interventions should be based on sufficient evidence of impact, thus giving unbiased estimates of economic efficiency. Hence the appropriate attribution of *causality of impact* is crucial, requiring a robust study design. Annex Table A2 presents alternative study designs for conducting economic evaluation studies, starting at the top with the most valid scientific approaches, down to the least valid at the bottom. Given that the most valid scientific approach (a randomized time-series intervention study) was not possible within the time frame and resources of this study, the most valid remaining option was to construct an economic model for a cost-benefit assessment of providing sanitation interventions and of moving from one sanitation coverage category to the next. A range of data was used in this model, reflecting both households with and without improved sanitation, to ensure that before and after intervention scenarios were most appropriately captured. This included capturing the current situation in each type of household (e.g. health status and health seeking, water practices, time use), as well as understanding attitudes towards improved and unimproved sanitation, and the factors influencing sanitation decisions. These data were supplemented with evidence from other local, national and international surveys and data sets on variables that could not be scientifically captured in the field surveys (e.g. behavior and risk factors for health assessment).

Figure 7 shows an overview of the methods for estimating the benefits of moving up the sanitation ladder. The actual size of the benefit will depend on the specific sub-type of sanitation intervention implemented.

The specific methods for the sanitation benefits are described below. For further details, refer to Annex Table A3.

**Health:** For the purposes of cost-benefit and cost-effectiveness analysis, three types of disease burden are evaluated: numbers of cases (incidence or prevalence), numbers of deaths, and disability-adjusted life-years (DALYs). Diseases included are all types of diarrheal disease, helminthes, scabies, malnutrition and diseases related to malnutrition (malaria, acute lower respiratory infection, measles) (see Annex Table A4). Health costs averted through improved sanitation are calculated by multiplying overall health costs per household by the relative risk to health reduction from improved sanitation and/or hygiene measures. Health costs are made up of disease treatment costs, productivity losses

**FIGURE 7:** OVERVIEW OF METHODS FOR ESTIMATING FIELD-LEVEL BENEFITS OF IMPROVED SANITATION

| BENEFIT CATEGORY | POPULATION WITH UNIMPROVED SANITATION | POPULATION WITH IMPROVED SANITATION | BENEFIT ESTIMATED |
|---|---|---|---|
| HEALTH | Data on health risk per person, by age category & socioeconomic status | Generic risk reduction, using international literature | Averted health care costs, reduced productivity loss, reduce deaths |
| WATER | Data on water source and treatment practices | Observed changes in practices in populations with improved sanitation | Reduced water sourcing and water treatment costs |
| ACCESS TIME | Data on time to access toilet per person per day | Observed reductions in time to access toilet | Opportunity cost of time applied to time gains |
| INTANGIBLES | Attitudes and preferences of householders to sanitation | Benefits cited of improved sanitation | Strength of preferences for different sanitation aspects and willingness to pay |
| REUSE | | Practices related to excreta reuse | Value gained, based on sales or own use |

and premature mortality losses. For a cost-effectiveness analysis, DALYs are calculated by combining the morbidity element (made up of disease rate, disability weight and illness duration) and the mortality element (mortality rate and life expectancy). Standard weights and disease duration are sourced from the Global Burden of Disease study, and average life expectancy at birth for China of 62 years is used (WHO, 2000).

- Rates of morbidity and mortality are sourced from various data sets for three age groups (0-4 years, 5-14 years, 15+ years), and compared and adjusted to reflect local variations in those rates. National disease and mortality rates were adjusted to rates used for the field sites based on socio-economic characteristics of sampled populations. As not all fecal-oral diseases have a pathway from human excreta, an attribution fraction of 0.88 is applied for these diseases. Methods for the estimation of disease and mortality rates from indirect diseases via malnutrition are provided in the ESI Impact Study report (Hutton et al 2008).
- Health care costs are calculated by applying treatment seeking rates for different health care providers to the disease rates, per population age group. The calculations also take into account hospital admission rates for severe cases. Unit costs of services and patient travel and sundry costs are applied based on treatment seeking.
- Health-related productivity costs are calculated by applying time off work or school to the disease rates, per population age group. The economic cost of time lost due to illness reflects an opportunity cost of time or an actual financial loss for adults with paid work. The unit cost values are based on the average income rates per location. For adults a rate of 30% of the average income is applied, reflecting a conservative estimate of the value of time lost. For children 5-14 years, sick time reflects lost time at school that has an opportunity cost, valued at 15% of the average income. For children under five, the time of the child carer is applied at 15% of the average income. Values are provided in Table 5.
- Premature death costs are calculated by multiplying the mortality rate by the unit value of a death. Although premature death imposes many costs on societies, it is difficult to value precisely. The method employed by this study – the human capital approach (HCA) – approximates economic loss by estimating the future discounted income stream from a productive person, from the time of death until the end of (what would have been) their productive life. In a sensitivity analysis, the value-of-statistical-life

(VOSL)[18] was estimated by adjusting by difference in GDP per capita levels to China from developed country studies. Values are provided in Table 5.

- Risk reductions of illness and death associated with improved sanitation and hygiene interventions are assessed from the international literature, and are applied and adjusted to reflect risk reduction in local settings based on baseline health risks and interventions applied. Risk reductions depended on whether the intervention provided a safe place to defecate without full isolation or treatment (basic sanitation), or whether a high degree of isolation and/or treatment was achieved (basic sanitation + wastewater management). The reductions in diarrheal disease, other fecal-oral diseases and diseases related to resulting malnutrition are as follows: basic sanitation alone (36%[19]), basic sanitation with hygiene (50%[20]), basic sanitation + wastewater management (56%[21]), and basic sanitation + wastewater management with hygiene (65%[22]). For soil-transmitted helminthes, fewer primary studies were available to estimate risk reductions; the following was assumed: basic sanitation alone (50%), basic sanitation with hygiene (70%), basic sanitation + wastewater management (80%), basic sanitation + wastewater management with hygiene (100%).

**Water:** While water has many uses at the community level as well as for larger-scale productive purposes (e.g. industry), the focus of the field study is use for domestic purposes, in particular drinking water. The most specific link between poor management of human excreta and water quality is the safety aspect, which causes communities to take mitigative actions to avoid consuming unsafe water. These include reducing reliance on surface water and greater use of wells or treated piped water supply. It even involves the need to rely less on shallow dug wells, which are more easily contaminated with pathogens, and to drill deeper wells. Water sources that communities traditionally relied on for their other domestic needs (such as cooking, washing, showering) are changed in favor of cleaner, but more expensive, water sources. Water quality measurement is conducted as part of this study in representative locations in Qiubei field site, to enable a detailed analysis of the impacts of improved

**TABLE 5:** AVERAGE UNIT VALUES FOR ECONOMIC COST OF TIME PER DAY AND OF LOSS OF LIFE (US$, 2009)

| Technique | Daily value of time | | | Value of life | | |
|---|---|---|---|---|---|---|
| | 0-4 years | 5-14 years | 15+ years | 0-4 years | 5-14 years | 15+ years |
| **RURAL SITES** | | | | | | |
| Human capital approach[1] | 1.77 | 1.77 | 3.54 | 21,376 | 33,453 | 35,058 |
| VOSL[2] | | | | 123,999 | 123,999 | 123,999 |
| **URBAN SITES** | | | | | | |
| Human capital approach[1] | 1.87 | 1.87 | 3.73 | 22,546 | 35,285 | 36,977 |
| VOSL[2] | | | | 130,789 | 130,789 | 130,789 |

[1] 2% real GDP or wage growth per year, discount rate = 8%
[2] The VOSL of US$2 million is transferred to the study countries by adjusting downwards by the ratio of GDP per capita in each country to GDP per capita in the USA. The calculation is made using official exchange rates, assuming an income elasticity of 1.0. Direct exchange from higher to lower income countries implies an income elasticity assumption of 1.0, which may not be true in practice.

[18] VOSL studies attempt to value what individuals are willing to pay to reduce the risk of death (e.g. safety measures) or willing to accept for an increase in the risk of death. These values are extracted either from observations of actual market and individual behavior ("hedonic pricing") or from what individuals stated in relation to their preferences from interviews or written tests ("contingent valuation"). Both these approaches estimate directly the willingness to pay of individuals, or society, for a reduction in the risk of death, and hence are more closely associated with actual welfare loss compared with the HCA.
[19] Thirty-six percent reflects the average of Waddington 2009, Fewtrell 2005, Esrey 1991 and Esrey 1996.
[20] Fifty percent reflects the sanitation interventions alone of 36% plus 14% add-on for hygiene.
[21] Fifty-six percent reflects the average for the two Brazilian studies which found a 43% and 69% risk reduction for high risk populations, and also is close to the 57% which is the half way risk reduction from scenario IV (or Vb) to scenario II (Prüss, 2002)
[22] Sixty-five percent reflects a 56% reduction from sanitation plus hygiene add-on which brings a 9% marginal impact.

sanitation on local water quality (see Annex Table A5). This study measures the actual or potential economic impacts of improving sanitation on two sets of mitigation measures:

- Accessing water from the source. Because households pay more or walk further to access water from cleaner sources such as drilled wells, or they pay more for piped water, it would in theory reduce these costs if sanitation was improved. For example, traditionally people prefer the taste of water from shallow wells to deeper wells, and hence would likely return to the use of shallow wells if they could guarantee cleaner, safer water. Also, providers of piped water have to treat water less if it is less contaminated, thus saving costs. Hence, expected percentage cost reductions are applied to current costs of clean water access to estimate cost savings from improved sanitation.
- Household treatment of water. Traditionally, in China many households treat their water due to concerns about safety and appearance. This is commonly true even for piped, treated water supplies. Boiling is the most popular method because it is perceived to guarantee water to be safe for drinking, and it is used for making tea. However, boiling water can require considerable cash outlays or it consumes their time for collecting fuel. Furthermore, boiling water for drinking purposes is more costly to the environment due to the use of wood, charcoal or electricity, with correspondingly higher carbon dioxide (CO2) emissions than other treatment methods. If sanitation is improved and the pathogens in the environment reduced to low levels, then households would feel more ready to use a simple and less costly household treatment method such as filtration or chlorination. Hence, based on observations and expected future household treatment practices under a situation of improved sanitation, the cost savings associated with alternative water treatment practices are calculated.

**Access time:** When households have their own private latrine, many of them will save time every day, compared to the alternative of going to the bush or using a shared facility. The time used for each sanitation option will vary from household to household, and from person to person, as children, men, women, and the elderly all have different sanitation preferences and practices. Therefore, this study calculates the time savings for different population groups of improving sanitation, based on observations of households both with and without improved sanitation. The value of time is based on the same values as health-related time savings (see above).

**Excreta reuse:** Human excreta, if handled properly, can be a safe source of fertilizer, wastewater for irrigation or aquaculture, or biogas. In four of the eight sites (three rural and one peri-urban), UDDTs have been provided, and biogas units were evaluated in three sites (all rural). The value of excreta reuse is measured through the assessment of the nonmarket value (when used by the household, given that the by-products are rarely sold or traded in the field sites). This enables calculation of an average value per household practicing human excreta reuse. In the case of combined human and animal excreta reuse (as with biogas), both the full cost and benefit of the biogas digester are included.

**Intangibles:** Intangibles are major determinants of personal and community welfare such as comfort, privacy, convenience, safety, status and prestige. Due to their often very private nature, intangibles are difficult to elicit reliable responses from individuals, and some may vary considerably from one individual and social group to another. Intangibles are therefore difficult to quantify and summarize from a population perspective, and are even more difficult to value in monetary terms for a cost-benefit analysis. Economic tools do exist for a quantitative assessment of intangible benefits such as contingent valuation method, and willingness to pay surveys are commonly used to value environmental goods. However, there are many challenges to the application of these methods in field settings which affect their reliability and validity, and ultimately appropriate interpretation of quantitative results. Furthermore, willingness to pay often captures more than just the intangible variables being examined, but also will capture preferences that have been valued elsewhere (e.g. health and water benefits). This current study therefore attempts only to understand and measure sanitation knowledge, practices and preferences in terms of ranking scales, on a simple scoring system of key characteristics between 1 (very poor) and

5 (very good), sourced from household surveys and focus group discussions. This enables a separate set of results to be provided alongside the monetary-based efficiency measures.

**External environment:** Likewise, the impacts of poor sanitation practices on the external environment are also difficult to quantify in monetary terms. Hence, this study attempts only to understand and measure practices and preferences in relation to the broader environment, in terms of ranking scales (see description in above paragraph). Given human-related sanitation is only one of several factors in environmental quality, other aspects – sources of water pollution, solid waste management, and animal waste – are also addressed to understand human excreta management within the overall picture of environmental quality.

### 3.3.4 DATA SOURCES

Given the range of costs and benefits estimated in this study, different data sources were identified including survey evidence from the field sites collected within the ESI study as well as evidence from other databases or studies. Due to certain limitations of the field study, elements of some benefits needed to be sourced from other more reliable sources. Routinely collected data such as the health information system are often of poor quality and incomplete, and hence were supplemented with evidence provided byWHO.

Data collection in field sites was conducted from 26 May to 28 June in 2009 in the eight sites. Sixteen graduate students under the direction of three researchers from Yunnan Academy of Social Sciences (YASS) formed the team. A training workshop on the questionnaire and household interviews was held for the interviewers, and field testing was conducted in Kunming. The research team benefited from the former contacts and relationships with most of the sanitation projects in Yunnan, and the Yunnan Environmental Protection Department played an important role in coordinating with sanitation projects at different levels for the study.

The contents of the field tools used are briefly introduced below.

**Field tool 1:** Household questionnaire. Household questionnaires consisted of two main parts: the first was asked to household representatives (the senior male and/or female household member, based on availability at the time of interview), while the second was a shorter observational component covering physical water, sanitation and hygiene features of the household. The oral interview consisted of questions on:

- Socio-economic and demographic information, and household features
- Current and past household sanitation options and practices, and mode of receipt
- Perceived benefits of sanitation, and preferences related to the external environment
- Household water supply sources, treatment and storage practices
- Health events and health treatment seeking
- Hygiene practices
- Household solid waste practices

The household questionnaire was applied to a total of 909 households over the eight sites, or roughly 114 households per site. In most locations, control sites were also established for comparison with project intervention sites. Annex Table A6 presents the sample sizes per sanitation option and per field site. The sample size has a minimum of 30 households for each sanitation option, and there are a total of eight sanitation options across all field sites. Considering the comparison of the same sanitation option among different sites, around 110 samples for each sanitation option are needed for the calculations. The option of "no sanitation" (open defecation) served as the control for each of the sanitation options – i.e. enabling comparison of indicators, conditions and preferences between with versus without sanitation scenarios. This sample was gathered from the field sites by calling a meeting of local community organizations and interviewing them individually. In both rural and urban areas, conducting face-to-face interviews was found to be challenging. In rural areas, heads of households were often hard to find or unavailable during the daytime, and in urban areas, some households refused to participate due to mistrust of strangers.

**Field tool 2:** Focus group discussion. The purpose of the focus group discussion (FGD) was to elicit behavior and preferences in relation to water, sanitation and hygiene from different population groups, with the main distinctions by sanitation coverage (with versus without) and gender (male and female). The topics covered in the FGDs followed a generic template of discussion topics, but the depth of discussion was dictated by the readiness of the participants to discuss the topics. The added advantage of the FGD approach is to discuss aspects of sanitation and hygiene that may not otherwise be revealed by face-to-face household interviews, and to either arrive at a consensus or otherwise to reflect the diversity of opinions and preferences for sanitation and hygiene among the population. Annex Table A7 shows the number of FGDs held per group per location – with a total of 190 participants distributed across 24 FGDs. Each FGD took approximately one hour.

**Field tool 3:** Physical location survey. A survey of the physical environment was conducted in 14 field locations across eight sites. The main purpose was to identify important variables in relation to water, sanitation and hygiene in the general environment, covering land use, water sources, and environmental quality. This information was triangulated with the household surveys and FGDs, as well as the water quality measurement survey, to enable appropriate conclusions about the extent of poor sanitation and links to other impact variables. This survey was conducted by an environmental engineer from the Yunnan Environment Science Institute.

**Field tool 4:** Water quality measurement. Given that one of the major impacts of poor sanitation is the impact on surface and ground water quality, special attention was paid in this study to identify the relationship between the type and coverage of toilets in the selected field sites, and the quality of local water bodies. Due to the time frame of the present study, it was not possible to measure water quality variables before the project or program was implemented; neither was it possible to compare wet season and dry season measurements. For reasons of cost and lack of available laboratories, water testing was only conducted in the sites of Qiubei City and Qiubei Rural. The water quality measurement survey was contracted to Wenshan Prefectural Hydrological Laboratory and carried out in July 2009. The study enabled the assessment of the impact of specific local sanitation features on water quality. It also enabled a broader comparison of water quality between study sites with different sanitation coverage levels. Water sources tested in both sites included ground water (dug shallow wells, deeper drilled wells), standing water (ponds, lakes, canals), and flowing water (rivers, wastewater channels). Annex Table A5 shows the type of test and location per parameter, and the number and type of water sources tested. Parameters measured varied per water source, but generally included biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), E.coli (Escherichiacoli), Total Coliform, pH, turbidity, $NH_3$-N (Ammonia-nitrogen), TN (Total Nitrogen) and TP (Total Phosphorus).

**Field tool 5:** Market survey. For economic evaluation, local prices are required to value the impacts of improved sanitation and hygiene. Selected resource prices, and in some cases resource quantities, were recorded from the most appropriate local source: labor prices (average wage, minimum wage) and employment rate, water prices by different sources, water treatment filters, fuel prices, sanitation improvement costs, soap costs, fertilizer costs (when excreta is used for fertilizer) and pharmacy drug costs.

**Field tool 6:** Health facility survey. Given the importance of health impacts, a separate survey was conducted in two to three health facilities serving each field site. Variables collected included numbers of patients with different types of water-related disease, and the types and cost of treatment provided by the facility. Data were supplemented by those collected or compiled at higher levels of the health system, such as the district or provincial levels.

**Other data sources:** As well as collection of data from field sites, data and information were collected from other sources to support the field-level cost-benefit study, such as reports, interviews, and data sets. These include:

- China Health Yearbook 2009
- Published papers in journals.

### 3.3.5 DATA ANALYSIS

The types of costs and benefits included in the study are listed in Section 3.2. This section describes how costs, benefits and other relevant data are analyzed to arrive at overall estimates of cost-benefits.

The field-level cost-benefit analysis generates a set of efficiency measures from site-specific field studies, focusing on actual implemented sanitation improvements, including household and community costs and benefits. The costs and benefits are estimated in economic terms for a 20-year period for each field site, using average values based on the field surveys and supplemented with other data or assumptions. Five major efficiency measures are presented:

1. The benefit-cost ratio (BCR) is the present value of the future benefits divided by the present value of the future costs, for a 20-year period. Future costs and benefits (i.e. beyond year one) are discounted to present a value using a discount rate of 8% (sensitivity analysis: low 3%, high 10%).
2. The cost-effectiveness ratio (CER) is the present value of the future health benefits in non-monetary units (cases, deaths, disability-adjusted life-years) divided by the present value of the future costs, for a 20-year period. Future costs and health benefits (i.e. beyond year one) are discounted to present a value using a discount rate (see above).
3. The internal rate of return (IRR) is the discount rate at which the present value equals zero – that is, the costs equal the benefits – for a 20-year period.
4. The payback period (PBP) is the time after which benefits have been paid back, assuming initial costs exceed benefits (due to capital cost) and over time benefits exceed costs, thus leading to a point that is break even.
5. The net present value (NPV) is the net discounted benefits minus the net discounted costs.

Results are presented by field site and for each sanitation improvement option compared with no sanitation option (i.e. open defecation). Also, selected steps up the sanitation ladder are presented, such as from shared latrine to private latrine, from dry pit latrine to wet pit latrine, or from wet pit latrine to sewerage. The efficiency ratios are presented both under conditions of well-delivered sanitation programs which lead to well-functioning sustainable sanitation systems, as well as sanitation systems and practices under actual conditions, observed from the program approach analysis (Section 3.4). Given that not all sanitation benefits have been valued in monetary units, these benefits are described and presented in non-monetary units alongside the efficiency measures.

## 3.4 PROGRAM APPROACH ANALYSIS

The aim of the program approach analysis (PAA) is to show the levels and determinants of performance of sanitation programs. It evaluates the link between different program approaches and the eventual efficiency and impact of the sanitation interventions. It is also used as the basis for adjusting ideal intervention efficiency to estimate actual intervention efficiency. The PAA also shows current practices in relation to sanitation program evaluation, and provides recommendations for improved monitoring and evaluation of sanitation programs.

The PAA is essentially a desk study assessment of sanitation program documents, with additional information gained through interviews with sanitation program managers and implementers. More in-depth studies and data were possible using the field sites for the cost-benefit analysis (see Section 3.3). The PAA has four main steps:

1. Listing of in-country sanitation programs and their characteristics, followed by a selection of sanitation programs to include in the PAA. Chapter 7.2 shows the selected programs and their main characteristics.
2. Assessment of specific types of program "approach" to be compared. The supply-driven approach, strategic planning approach and demand-led approach are compared in the study in order to identify the effectiveness of the different program approaches.
3. Evaluation of selected sanitation programs in terms of their programming approach and measures of output and success (e.g. unit costs, coverage, uptake). For the assessment of actual efficiency, key indicators of program effectiveness are selected.
4. Analysis of factors determining program performance, focusing on economic variables.

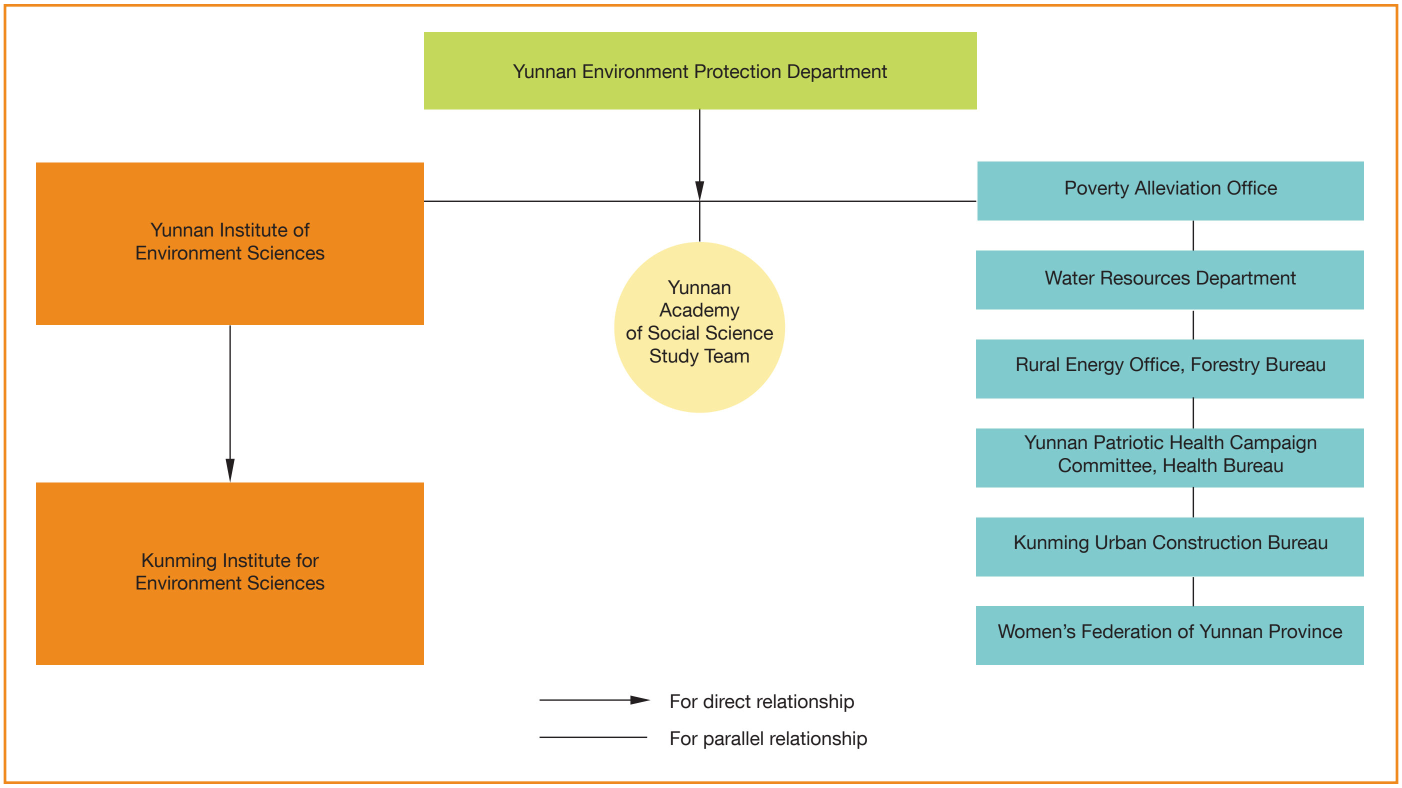
The PAA is constrained by a lack of data on inputs, outputs and outcomes available from programs evaluated, which limits the number of programs that could be included in the study. The results of the analysis are interpreted taking into account setting-specific conditions which are partially responsible for the performance results; hence findings are not definitive, but instead illustrative and instructive.

## 3.5 STEERING AND COLLABORATION

The multi-sectoral focus, innovative methods and skill mix required made this research study very challenging. The overall management structure includes four levels: coordination support by the Yunnan Environmental Protection Department (YEPD), organization and implementation by YASS, collaboration with and among the sectors of the governments as stakeholders of the study, and the internal coordination of the research team (see Figure 8). YEPD coordinated multi-sectoral collaboration among the different governmental agencies, and was responsible for disseminating the study results. Through formal consultations to different agencies, YEPD helped contribute to the research design, provide data, and interpret and use the study results.

Involving sector stakeholders is important in evaluating alternative policy options from an early stage. The joint evaluation with the sector stakeholders on the policies and implementation mechanisms has consolidated the study result, and promoted the awareness among sector stakeholders on the importance of public investment in sanitation as well as the need for efficiency improvement. YEPD also played an important role in selecting field sites. The Human and Environmental Action Research Office at YASS played a leading role in the formulation of study outputs. The role of YEPD was to coordinate inputs from the different government agencies. Workshops were held to conduct joint discussions and to share field study results with the stakeholders, producing policy recommendations to the governments.

**FIGURE 8:** DIAGRAM OF COLLABORATION OF ESI TEAM WITH STAKEHOLDER AGENCIES IN YUNNAN, CHINA



# IV. Local Benefits of Improved Sanitation and Hygiene

This chapter presents the following community- and household-level impacts of improved sanitation and hygiene:

- Health (Section 4.1)
- Water (Section 4.2)
- Access time (Section 4.3)
- Reuse of human excreta (Section 4.4)
- Intangibles Sanitation Preferences (Section 4.5)
- External environment (Section 4.6)

## 4.1 HEALTH

### 4.1.1 DISEASE BURDEN OF POOR SANITATION AND HYGIENE

According to the WHO, water, sanitation and hygiene-related diseases lead to more than five million premature deaths globally every year. Fecal-oral diseases are one major set of water-related disease, and intestinal nematodes (or helminthes) are another. It is increasingly recognized that these water-related diseases are a major cause of malnutrition worldwide, being responsible for 50% of malnutrition (WHO), which leads to a higher incidence or fatality rate of diseases which are not traditionally linked to fecal-oral disease. According to WHO 88% of diarrhea incidence is due to unsafe drinking water, poor hygiene practice and sanitation facilities, causing one and a half million annual deaths globally. The number of children dying before their fifth birthday is 860,000 every year globally. It is estimated that approximately two billion people suffer from helminthes including schistosomiasis, ascariasis and ancylostomiasis. Twenty-five million people are seriously disabled due to lymphatic filariasis (LF), and two thirds of LF cases are due to a lack of safe water, improved sanitation and hygiene[23]. Five million people can avoid trachoma, 200 million can avoid schistosomiasis infection, and malaria incidence can be reduced by 40%[24].

In China, there are more than 50 diseases related to unsafe drinking water, and the rural residents are more prone than urban residents to these diseases due to the poorer quality of drinking water and inadequate sanitation and hygiene[25]. In general, the incidence of these diseases is lower in China in comparison with other developing countries in Asia. According to the available data, 1.5% of deaths and 3% of disease burden (including diarrhea, Hepatitis A, Hepatitis E, trachoma, and Helminthes) were directly related to poor water supply and sanitation in 1990[26].

Annually, in rural sites, it is estimated that there are 1.9 cases of disease per person, 16 DALYs per 1,000 population and an annual risk of death of 0.92 per 1,000 people due to poor sanitation and hygiene (see Table 6). In urban areas the rates are lower, at 1.4 cases of disease per person, 13 DALYs per 1,000 people, and an annual risk of death of 0.67 in 1,000 people. In peri-urban areas, the rate is 1.5 cases of disease per person, 12 DALYs per 1,000 people, and an annual risk of death of 0.69 per 1,000 people. Site-specific rates used are in Annex Table B1.

To some extent, quality of life impacts associated with morbidity are reflected in the DALY calculations above[27], and in the estimates of health care and productivity costs (see later sections). These diseases affect people's health, and cause pain and mental suffering. Some patients lose their ability to work, have to borrow money to pay treatment costs, and risk falling into the poverty trap. Some infectious diseases

[23] http://www.un.org/chinese/News/fullstorynews.asp?newsID=10025
[24] http://www.yigan1.com/ygzz/ygzz_20090427095132.html
[25] http://news.xinhuanet.com/politics/2006-09/04/content_5046923.htm
[26] http://www.stuln.com/huanbaozhichuang/hbjy/hbgs/2009-3-13/Article_29681.shtml
[27] DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for incident cases of the health condition.

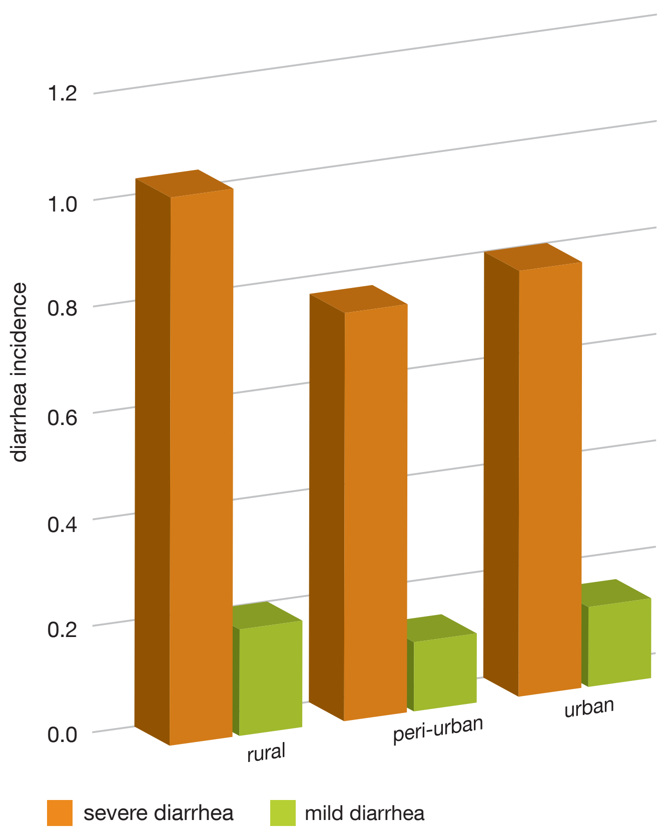
**TABLE 6:** ANNUAL DISEASE MORBIDITY AND MORTALITY ATTRIBUTABLE TO POOR SANITATION AND HYGIENE, 2008

| Disease | Rural | | | Urban | | | Peri-urban | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cases/ person | Mortality/ 1,000 pop. | DALYs/ 1,000 pop. | Cases/ person | Mortality/ 1,000 pop. | DALYs/ 1,000 pop. | Cases/ person | Mortality/ 1,000 pop. | DALYs/ 1,000 pop. |
| Mild diarrhea | 0.767 | 0.01 | 1.1 | 1.033 | 0.01 | 1.5 | 0.800 | 0.01 | 1. 2 |
| Severe diarrhea | 0.133 | 0.13 | 2.2 | 0.200 | 0.20 | 3.3 | 0.150 | 0.15 | 2.4 |
| Helminthes | 0.373 | 0.37 | 6.6 | 0.387 | 0.39 | 6.4 | 0.360 | 0.36 | 5.9 |
| Scabies | 0.001 | 0.00 | 0.01 | 0.001 | 0.00 | 0.01 | 0.001 | 0.00 | 0.01 |
| Trachoma | 0.100 | 0.10 | 1.1 | 0.100 | 0.10 | 1.1 | 0.100 | 0.10 | 1. 1 |
| Hepatitis A,E | 0.001 | 0.00 | 0.6 | 0.001 | 0.00 | 0.6 | 0.001 | 0.00 | 0.6. |
| Malnutrition | 0.010 | 0.01 | 0.1 | 0.010 | 0.01 | 0.1 | 0.010 | 0.01 | 0.1 |
| Malaria | 0.002 | 0.00 | 0. | 0.100 | 0.10 | 1. 3 | 0.001 | 0.00 | 0.01 |
| ALRI | 0.040 | 0.03 | 1.4 | 0.100 | 0.10 | 1.4 | 0.050 | 0.05 | 0.7 |
| Measles | - | 0.01 | 0.1 | - | 0.01 | 0.1 | - | 0.01 | 0.1 |
| Other indirect | - | 0.01 | 0. 1 | - | 0.01 | 0.1 | - | 0.01 | 0.1 |
| **Total** | **1.427** | **0.67** | **13.2** | **1.932** | **0.92** | **16.8** | **1.473** | **0.69** | **12.2** |

Data source: ESI and World Bank, see Annex table B1, B2 and B3. Pop - population

can be transmitted to animal stocks, which when affected can risk household income and social stability. Households therefore take disease preventive measures they know about. For example, the survey found that 95% of the respondents boil water for drinking and clean containers to feed infants. Figure 9 shows that the rate of diarrheal incidence in rural areas is the highest.

**FIGURE 9:** COMPARISON BETWEEN STUDY SITES OF DIARRHEAL DISEASE INCIDENCE FOR UNDER FIVES, 2008




Data Source: ESI. See health data sets and Annex Table B1

### 4.1.2 HEALTH CARE COST

Health care costs are estimated based on disease cases, the proportion of illnesses treated by each provider, and the unit costs associated with each provider. Table 7 shows a summary of treatment seeking rates from different data sources. The evidence from both the ESI survey and the Health Statistic Yearbook suggests that the majority of the population seeks care from public providers and private formal clinics. However, in some cases they differ since the data from the Yearbook is province-wide, while ESI data draw on the surveys of the field sites. For instance, the ESI survey shows that 10% of patients choose pharmacies, in comparison to 1% from the Health Statistic Yearbook. In these cases, the Yearbook's statistics were used as the source of data for treatment seeking, given they better reflect the province-wide situation. The tables in Annex Table B7 show treatment seeking behavior for other diseases.

**TABLE 7:** FIRST HEALTH PROVIDER VISITED FOR TREATMENT, FOR SELECTED DISEASES (ALL AGE GROUPS)

| Data source | Obs. | % seeking treatment from | | | | | No treatment | Total |
|---|---|---|---|---|---|---|---|---|
| | | Public provider | Private formal clinic | Informal care | Pharmacy | Self-treatment | | |
| RURAL AREAS | | | | | | | | |
| ESI sites (diarrheal disease only)[1] | 215 | 20 | 30 | 20 | 20 | 9 | 1 | 100 |
| Yunnan Province (all diseases)[2] | - | 41 | 30 | 10 | 10 | 9 | 1 | 100 |
| URBAN AREAS | | | | | | | | |
| ESI sites (diarrheal disease only)[1] | 185 | 40 | 10 | 20 | 10 | 20 | 0 | 100 |
| Yunnan Province (all diseases)[2] | - | 49 | 17 | 16 | 1 | 15 | 2 | 100 |
| PERI-URBAN AREAS | | | | | | | | |
| ESI sites (diarrheal disease only)[1] | 150 | 38 | 12 | 20 | 10 | 20 | 0 | 100 |

Data source: [1]ESI survey (2009) and [2]China Health Statistic Yearbook (2009). Obs. - observations

**TABLE 8:** UNIT COSTS ASSOCIATED WITH TREATMENT OF SEVERE DIARRHEA (US$, 2009)

| Health provider | Outpatient cost | | Inpatient cost | | |
|---|---|---|---|---|---|
| | Health care | Incidentals[1] | ALOS[2] | Health care (per day) | Incidentals[1] (per case) |
| PUBLIC/NGO | | | | | |
| Rural | 15.62 | 0.29 | 0.44 | 34.11 | 5.86 |
| Peri-urban | 15.62 | 0.73 | 0.44 | 39.23 | 4.68 |
| Urban | 15.62 | 0.73 | 0.44 | 39.23 | 2.93 |
| PRIVATE FORMAL | | | | | |
| Rural | 7.76 | 0.29 | 0.44 | 23.42 | 4.39 |
| Peri-urban | 11.71 | 0.73 | 0.44 | 26.35 | 2.93 |
| Urban | 13.61 | 0.73 | 0.44 | 26.35 | 2.20 |
| PHARMACY | | | | | |
| Rural | 4.39 | 0.73 | - | - | - |
| Peri-urban | 4.39 | 0.59 | - | - | - |
| Urban | 4.39 | 0.29 | - | - | - |

[1]Incidentals: non-health patient costs such as transport, food, and incidental expenses, per outpatient visit and per inpatient stay; [2]ALOS: average length of stay; [3]Inpatient health care costs are presented per stay
Data source:"2009 China Health Statistic Yearbook," and supplemented by interviews with doctors and patients, and annex table B8, B9 and B10.

Table 7 shows that there are disparities between the ESI survey and the 2009 Health Statistic Yearbook. The proportion seeking treatment from public providers in rural areas from ESI is much less than that from the Health Statistic Yearbook. However, the rate of the ESI survey is much higher than that of the 2009 China Health Statistic Yearbook for seeking treatment from informal care, pharmacies and self treatment. In this study, the treatment seeking rate is from the 2009 China Health Statistic Yearbook, as the field survey data are not sufficient for other diseases except diarrhea. It is illustrated by a statistical analysis that the difference between the rural population and urban population in treatment seeking behavior is significant ($P<0.001$). People from rural areas are much more likely to seek treatment from private clinics and other informal types of treatment than people from urban and peri-urban areas. In particular, the rural population will not go to public health providers for inpatient treatment until the diseases get severe. According to the ESI survey, 20% of the rural population choose public providers, which is half that of urban populations (40%). This is due to travel costs, proximity of public hospitals, and cost of treatment. Thirty percent of the rural population chooses private formal clinics for treatment, 20% informal care and 9% self-treatment. Twenty percent of the urban population choose self-treatment. The average rate of inpatient care is around 1% of the sick persons when their conditions reach severe stages, according to the 2009 China Health Statistic Yearbook.

Unit costs for treatment of severe diarrheal disease are provided in Table 8 by health care providers. Health care costs for public providers of outpatient care have little difference among the different sites, but formal treatment costs vary among urban, peri-urban and rural areas. Private formal treatment in urban areas is the most expensive, followed by peri-urban areas and rural areas. Health care costs for public providers are more expensive than private formal treatment, partly explaining why the rural population often opts for private treatment first. The incidental costs vary between locations, as the transportation in urban and peri-urban areas is more convenient and cheaper. The health care costs for different providers correspond with treatment seeking behavior. For the same disease, the pharmacy cost is similar. But for different diseases, the pharmacy cost varies a lot, as some of the diseases have a long duration. For example, the pharmacy cost of treating Hepatitis is around US$500.

Annual costs per person vary by age group, and are estimated to range from US$22 to US$52 in rural areas, from US$17 to US$39 in urban areas and US$14 to US$37 in peri-urban areas. On average, the cost per person is highest in rural areas, and among the under-five age group. Interestingly, one of the most expensive diseases is ALRI – which is an indirect disease whose risks are increased through malnutrition, but whose unit costs of treatment are higher than the direct and more common diarrheal disease.

**TABLE 9:** ANNUAL COSTS PER PERSON (BY AGE GROUP) ATTRIBUTED TO POOR SANITATION AND HYGIENE IN YUNNAN (US$, 2009)

| Disease | Rural | | | Urban | | | Peri-urban | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0-4 yrs | 5-14 yrs | 15+ yrs | 0-4 yrs | 5-14 yrs | 15+ yrs | 0-4 yrs | 5-14 yrs | 15+ yrs |
| Diarrheal disease mild | 13.17 | 8.91 | 6.74 | 9.45 | 8.49 | 5.44 | 8.42 | 4.63 | 3.74 |
| Diarrheal disease severe | 8.51 | 6.58 | 2.33 | 8.16 | 5.59 | 1.72 | 6.46 | 4.83 | 2.41 |
| Helminthes | 5.64 | 6.77 | 4.37 | 5.69 | 6.79 | 5.38 | 3.90 | 4.68 | 2.96 |
| Hepatitis A, E | 0.42 | 0.34 | 0.34 | 0.45 | 0.36 | 0.36 | 0.29 | 0.29 | 0.29 |
| Scabies | 0.72 | 0.84 | 0.84 | 0.71 | 0.85 | 0.85 | 0.48 | 0.48 | 0.48 |
| Trachoma | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Malnutrition | 2.93 | 0.72 | 0.36 | 2.99 | 0.71 | 0.36 | 1.92 | 0.55 | 0.27 |
| Malaria | 2.83 | 1.16 | 1.16 | 0.84 | 0.06 | 0.02 | 1.74 | 0.36 | 0.35 |
| ALRI | 18.13 | 9.46 | 5.66 | 10.68 | 4.99 | 2.62 | 13.33 | 6.54 | 3.27 |
| **Total** | **52.37** | **34.80** | **21.80** | **38.99** | **27.85** | **16.76** | **36.55** | **22.37** | **13.78** |

Data source: health data sheets of rural, peri-urban and urban areas of ESI.

**TABLE 10:** AVERAGE PRODUCTIVITY COST PER PERSON PER YEAR IN FIELD SITES, BY DISEASE, AGE GROUP AND RURAL/URBAN LOCATION (US$, 2009)

| Disease | Rural | | | Urban | | | Peri-urban | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0-4 yrs | 5-14 yrs | 15+ yrs | 0-4 yrs | 5-14 yrs | 15+ yrs | 0-4 yrs | 5-14 yrs | 15+ yrs |
| Diarrheal disease mild | 8.72 | 4.93 | 7.25 | 6.50 | 4.44 | 5.61 | 5.03 | 2.75 | 3.85 |
| Diarrheal disease severe | 3.82 | 2.94 | 2.01 | 3.49 | 2.34 | 1.44 | 1.98 | 1.44 | 1.09 |
| Helminthes | 3.54 | 4.24 | 5.46 | 3.45 | 4.11 | 6.38 | 2.39 | 2.87 | 3.44 |
| Hepatitis A, E | 0.02 | 0.03 | 0.06 | 0.02 | 0.03 | 0.06 | 0.01 | 0.02 | 0.04 |
| Scabies | 0.71 | 0.71 | 1.41 | 0.75 | 0.75 | 1.49 | 0.48 | 0.48 | 0.96 |
| Trachoma | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 |
| Malnutrition | 0.50 | 0.14 | 0.14 | 0.52 | 0.15 | 0.15 | 0.33 | 0.10 | 0.10 |
| Malaria | 2.16 | 0.81 | 1.63 | 0.69 | 0.04 | 0.03 | 0.84 | 0.03 | 0.01 |
| ALRI | 10.93 | 6.02 | 7.29 | 5.57 | 2.85 | 2.96 | 6.22 | 2.46 | 2.46 |
| **Total** | **30.39** | **19.83** | **25.26** | **20.99** | **14.71** | **18.14** | **17.29** | **10.14** | **11.96** |

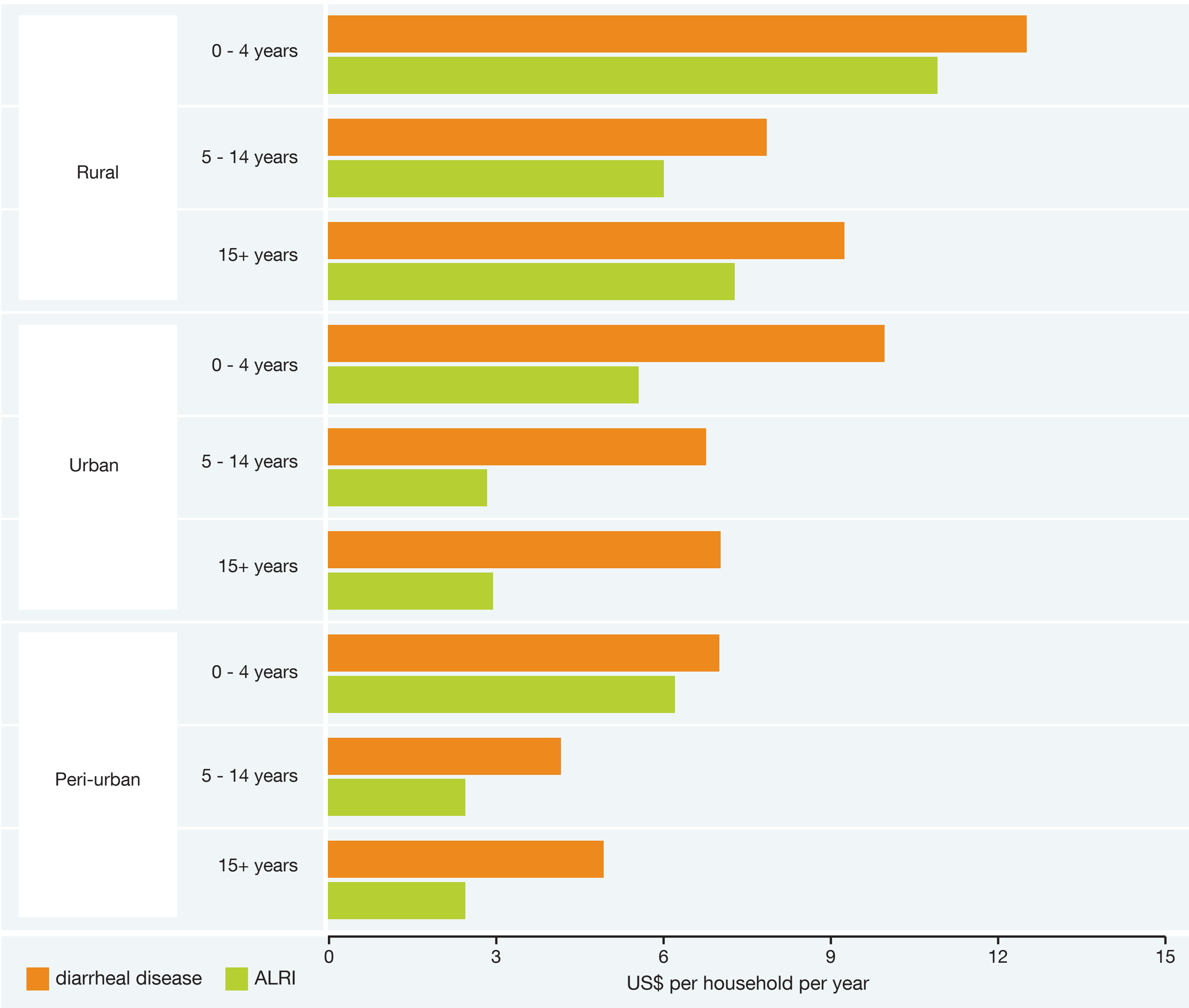
### 4.1.3 HEALTH-RELATED PRODUCTIVITY COST

Table 10 shows average productivity cost per person per year in the field sites, by disease, age group and locations. The value is calculated based on disease incidence (disease cases per person per year), time off productive activity due to disease, and opportunity cost of time. The result shows that productivity lost of rural populations due to the disease is the highest followed by peri-urban populations. Figure 10 shows that productivity costs of ALRI and diarrheal disease are similar.

### 4.1.4 PREMATURE MORTALITY COST

Table 11 shows the average mortality cost per person per year, calculated as the annual risk of mortality per field location and age group multiplied by the estimated value of life. The average value varies significantly across age groups, with children under five having the highest premature mortality cost. Diarrheal disease and helminthes have the highest premature mortality cost. For a total value of the premature mortality cost caused by the diseases, the 0-4 age group in rural areas has the highest average mortality cost per person per year at US$280, urban areas have a lower cost at US$254, and peri-urban areas at US$166.

**FIGURE 10:** COMPARISON OF THE PRODUCTIVITY COST BETWEEN STUDY SITES OF ALRI AND DIARRHEAL DISEASE, 2009



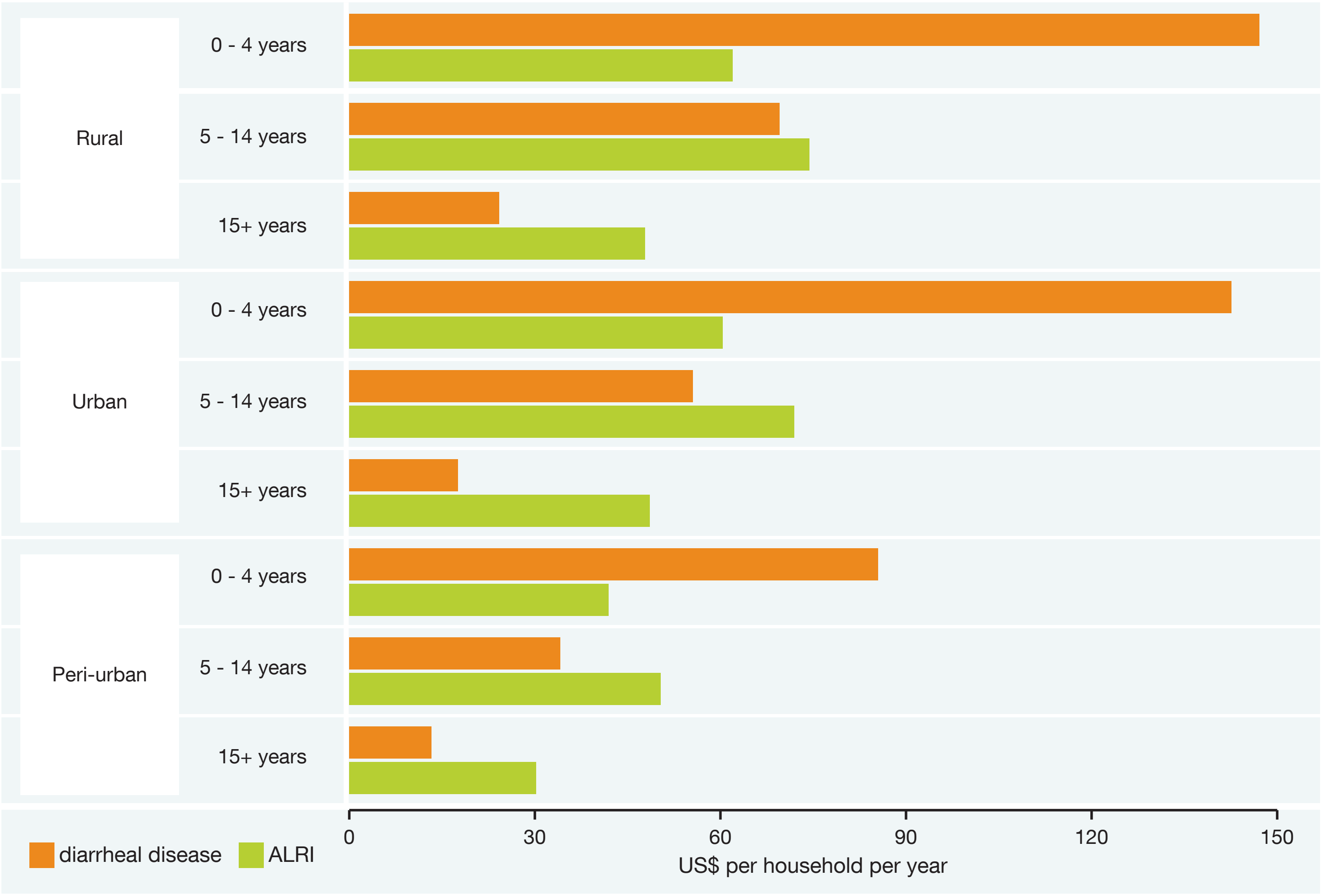

Data source: see Table 11

**TABLE 11:** AVERAGE MORTALITY COST PER PERSON PER YEAR IN FIELD SITES, BY DISEASE, AGE GROUP AND RURAL/URBAN LOCATION (US$, 2009)

| Disease | Rural | | | Urban | | | Peri-urban | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0-4 yrs | 5-14 yrs | 15+ yrs | 0-4 yrs | 5-14 yrs | 15+ yrs | 0-4 yrs | 5-14 yrs | 15+ yrs |
| Diarrheal disease mild | 57.93 | 0.79 | 0.79 | 61.11 | 0.83 | 0.83 | 39.18 | 0.53 | 0.53 |
| Diarrheal disease severe | 89.16 | 68.75 | 23.47 | 81.47 | 54.69 | 16.77 | 46.32 | 33.55 | 12.77 |
| Helminthes | 62.00 | 74.40 | 47.85 | 60.39 | 71.97 | 48.56 | 41.93 | 50.32 | 30.19 |
| Hepatitis A, E | 0.12 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.08 | 0.08 | 0.08 |
| Scabies | 12.40 | 12.40 | 12.40 | 13.08 | 13.08 | 13.08 | 8.39 | 8.39 | 8.39 |
| Trachoma | 0.12 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.08 | 0.08 | 0.08 |
| Malnutrition | 8.68 | 2.48 | 1.24 | 9.16 | 2.62 | 1.31 | 5.87 | 1.68 | 0.84 |
| Malaria | 32.87 | 12.40 | 12.40 | 10.58 | 0.65 | 0.26 | 12.77 | 0.42 | 0.04 |
| ALRI | 10.38 | 20.47 | 12.40 | 10.94 | 9.70 | 14.27 | 7.02 | 8.39 | 4.19 |
| Measles | 0.84 | 0.62 | 0.62 | 0.89 | 0.65 | 0.65 | 0.57 | 0.42 | 0.42 |
| Others | 5.38 | 3.72 | 0.62 | 5.68 | 3.92 | 0.65 | 3.64 | 2.52 | 0.42 |
| **Total** | **279.90** | **196.27** | **112.03** | **253.55** | **158.38** | **96.64** | **165.85** | **106.37** | **57.96** |

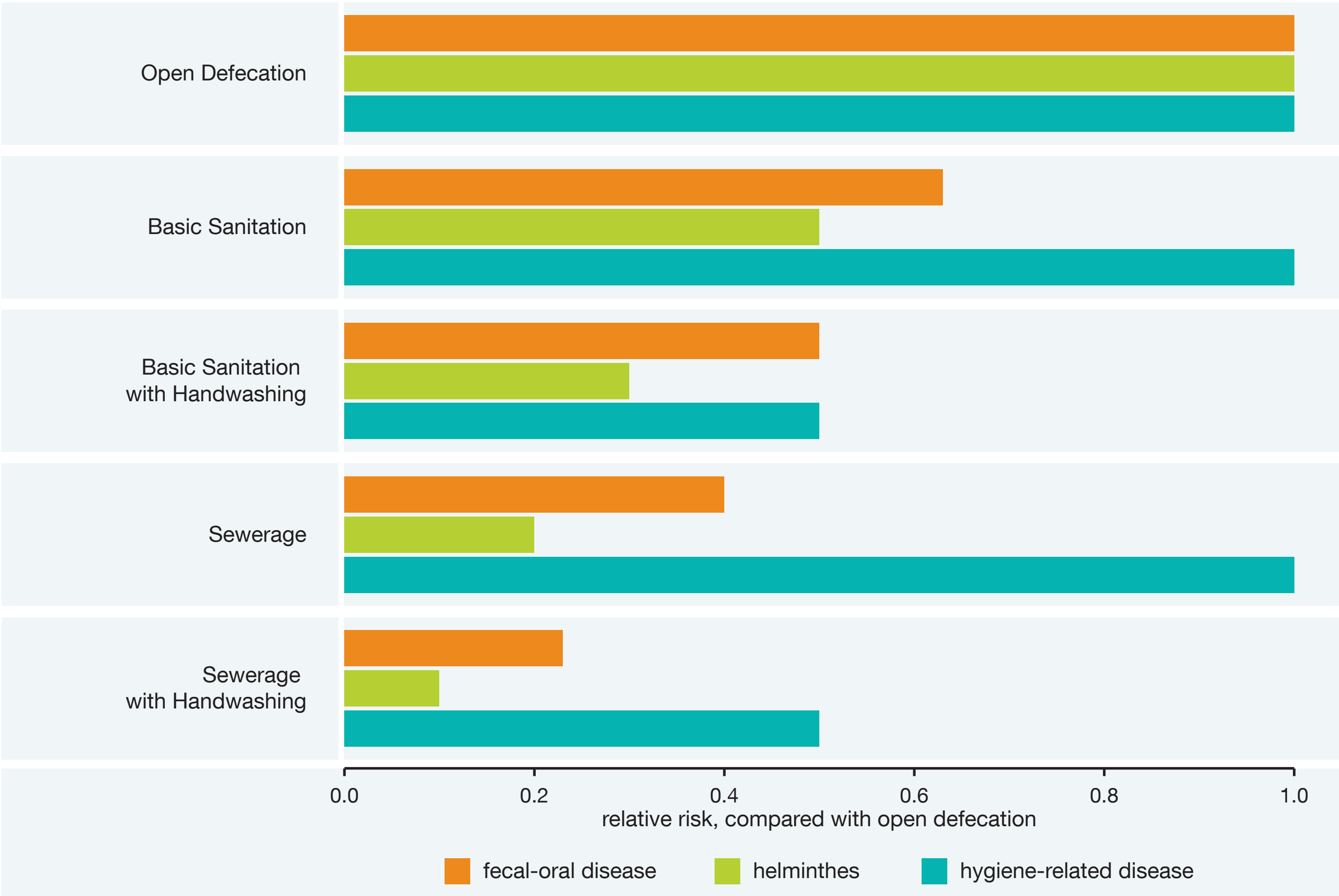
Data source: Data sheets of cost of health impacts in ESI.

**FIGURE 11:** COMPARISON OF PREMATURE MORTALITY COST BETWEEN STUDY SITES OF HELMINTHES AND DIARRHEAL DISEASE 2009




Data source: see Table 12

**FIGURE 12:** RELATIVE RISK OF FECAL-ORAL DISEASES AND HELMINTHES OF DIFFERENT RISK EXPOSURE SCENARIOS




### 4.1.5 AVOIDED HEALTH COST

Central to the arguments of improving sanitation and hygiene are the health effects. Limited evidence exists on the actual impact of sanitation or hygiene programs on health outcomes in China and this study draws on international evidence (see Methods Section). Figure 12 shows the different risk exposure scenarios being compared in this study, and the relative risk of fecal-oral disease and helminthes infection associated with each scenario. The left-hand side scenarios (basic improved sanitation) are relevant mainly for rural areas, while the right-hand side scenarios (moving to treatment of sewage and wastewater) are relevant mainly for urban areas.

Figure 12 shows the different risk exposures to fecal-oral disease, to helminthes and to other hygiene-related diseases according to sanitation and hygiene coverage. Sewerage and hygiene measures can together reduce helminthes incidence significantly (90% reduction selected in this study), while basic sanitation with hygiene can reduce it by 50%. It has been proved that improved sanitation and hygiene are crucial to improved human health.

Table 12 presents results from a question in the household survey "have you noticed an observable change in diarrhea disease rates in any household members since you received the new latrine?" The response shows that 29% to 59% of households answered "yes". The effect appears to be larger for those receiving shared or public latrines, possibly because they did not have toilets before, whereas those receiving new septic tanks or sewerage connections are more likely to have had basic sanitation already.

Table 13 summarizes the total costs per household of improved sanitation and hygiene in Yunnan for rural, peri-urban and urban field sites. The averted costs are calculated by multiplying the total costs of disease by the proportional reduction, per disease.

**TABLE 12:** PERCEIVED DIFFERENCE IN DIARRHEA INCIDENCE SINCE IMPROVED SANITATION, IN ALL FIELD SITES

| Sanitation coverage | Households in sample | Answer to question "have you noticed an observable change in diarrhea disease rates in any household members since you received the new latrine?" | | |
|---|---|---|---|---|
| | | Yes | No | Don't know |
| Shared/public | 118 | 58.5% | 11.9% | 4.2% |
| Pit latrine | 203 | 25.6% | 18.2% | 1% |
| Septic tank | 242 | 28.9% | 23.6% | 1.7% |
| Flush to Sewerage | 93 | 31.2% | 22.6% | 2.2% |

**TABLE 13:** ANNUAL COSTS PER HOUSEHOLD OF POOR SANITATION AND HYGIENE, AND ANNUAL COSTS AVERTED OF IMPROVED SANITATION (US$, 2009)

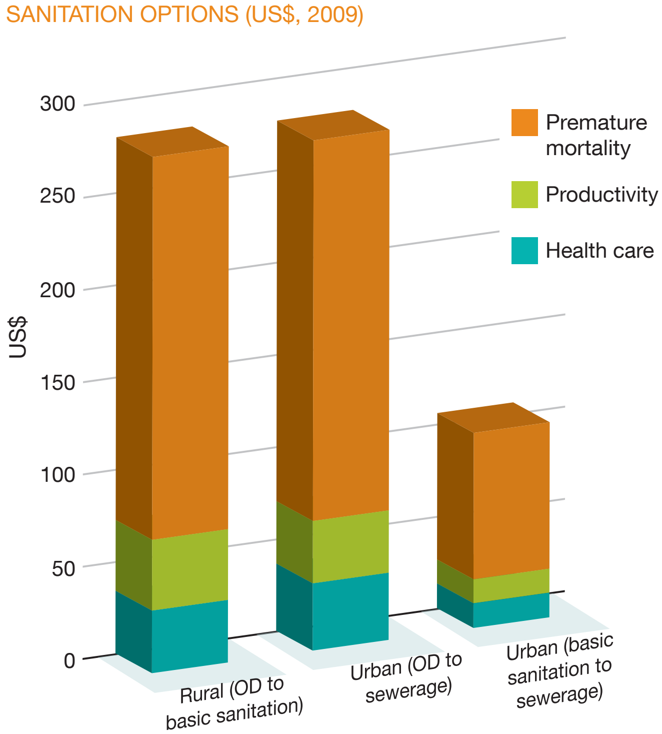
| Costs (US$) | Costs averted | | | | |
|---|---|---|---|---|---|
| | Rural (OD to basic sanitation) | Urban (OD to sewerage) | Urban (OD to basic) | Urban (basic sanitation to sewerage) | Peri-urban (OD to basic sanitation) |
| Health care | 33.94 | 36.44 | 23.03 | 13.42 | 26.74 |
| Productivity | 38.36 | 33.81 | 20.84 | 12.97 | 25.14 |
| Premature mortality | 207.47 | 206.25 | 126.91 | 79.34 | 143.66 |
| **Total** | 280. | **277** | **171** | **106** | **196** |

Table 13 shows that the averted cost from OD to basic sanitation for rural households is US$280 per year. In urban areas, moving from OD to a sewerage system may avert US$277 per year for an average household, while moving from basic sanitation to sewerage may avert US$106. In peri-urban areas, moving from OD to basic sanitation may avert US$196 per year. It has shown that the living standards and health level can be highly improved by moving from open defecation to basic sanitation.

## 4.2 WATER

This section provides an overview of water resources in Yunnan Province, including rivers, lakes and ground water. It draws on government data[28], and focuses on urban areas. Information collected from ESI surveys enables estimation of costs associated with water pollution at household level in the eight field sites, and estimates costs avoided through improved sanitation.

**FIGURE 13:** HEALTH COSTS AVERTED OF IMPROVED SANITATION OPTIONS (US$, 2009)




[28] 2008 Yunnan Annual Environmental Status Briefing Report, Yunnan Environmental Protection Department, June 2009; Yunnan Infrastructure Construction Plan for Urban Domestic Wastewater Treatment and Reuse (2008 -2012), Yunnan Housing, Urban and Rural Development Department, 2006; 11th-Five Year Plan for Water Pollution Prevention and Control in Dianchi Watershed, Ministry of Environmental Protection, May 2003; Rural Water Supply and Sanitation Survey Report – Yunnan, Yunnan Patriotic Health Campaign Committee (YPHCC), October 2007; Yunnan Water Resources in Brief, Yunnan Water Resources Department, December 2008

### 4.2.1 WATER RESOURCES IN YUNNAN PROVINCE

Yunnan Province is a relatively "water rich" province in China. In 2008, internal freshwater resources per capita per year were 5,059 $m^3$, which is significantly higher than the average across China of 2,200 $m^3$. In Yunnan Province, 908 rivers, comprising a catchment area larger than 100 $km^2$, drain into the Yangtze, Pearl, Red River, Mekong, Salween, and Irrawaddy water basins. There are more than 40 lakes in Yunnan with a total storage capacity of 29 billion $m^3$, including the nine most important lakes - Dianchi, Erhai, Fuxian, Chenghai, Lugu, Yilong, Qilu, Yangzong and Xingyun, each having a surface area larger than 30 $km^2$.

The average water resource per capita in Yunnan is generally high, but it is unevenly distributed. In the most populated and economically developed regions, such as the center of the province, the average water resource per capita is 700 $m^3$, while in Dianchi watershed it is 276 $m^3$ per capita (Yunnan Water Resource Department, December 2008).

Among these three study sites, Kunming and Dali are the more economically developed areas in Yunnan, but water resources available there are less than in Wenshan Prefecture, to which Qiubei County belongs. A comparison of water sources at these sites is given in Table 14. Per capita and by total volume, Kunming is now the most water scarce area of Yunnan. Water pollution is placing additional pressure on the water shortage to this region.

In rural areas of Yunnan, available drinking water sources differ from region to region. In general, surface water is almost as important as ground water as a source of drinking water in the province. However, in Dali, 87% of drinking water comes from ground water while in Qiubei it accounts for only 9% of the total drinking water share. Table 15 provides an overview of different drinking water sources in three regions.

**TABLE 14:** OVERVIEW OF WATER RESOURCES OF THREE SELECTED STUDY SITES

| Administrative | Water resources by region (billion $m^3$) | Water resources per capita ($m^3$) |
|---|---|---|
| Kunming | 6.9 | 1,114 |
| Wenshan Prefecture[1] | 18.2 | 5,304 |
| Dali Prefecture[2] | 12.2 | 3,484 |
| Yunnan Province | 231.4 | 5,095 |

[1] Where Qiubei County belongs to.
[2] Where Dali City/Municipality belongs to.

**TABLE 15:** DRINKING WATER SOURCES IN ESI STUDY SITES

| Region | Population ('000) | Surface water (%) | | | | | | Ground water (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | River | Lake | Reservoir | Pond | Cistern | Sub-total | Bore hole | Spring | Dug well | Sub-total |
| Kunming– Anning City | 137 | 0 | 0 | 36.3 | 5.1 | 0 | 41.4 | 12.9 | 45.7 | 0 | 58.6 |
| Kunming– Songming County | 312 | 0 | 0 | 44.9 | 8.7 | 0 | 53.5 | 6.9 | 25.7 | 13.8 | 46.5 |
| Qiubei County | 425 | 3.25 | 0 | 3.0 | 62.4 | 22.42 | 91.1 | 0.8 | 0 | 8.1 | 8.9 |
| Dali City | 379 | 0 | 13.1 | 0 | 0 | 0 | 13.1 | 0.6 | 41.4 | 44.9 | 86.9 |
| Yunnan Province | 8,940 | 3.58 | 0.73 | 17.9 | 21.0 | 5.39 | 48.6 | 2.4 | 25.8 | 23.2 | 51.4 |

Notes:
1) Source: Rural Water Supply and Sanitation Survey Report – Yunnan, YPHCC, October 2007
2) In Kunming two study sites: Anning City and Songming County were surveyed, therefore data collected there were used to represent the greater Kunming region.
3) Data were collected between August and October 2006.
4)Population given in the table reflects the total population of the corresponding site. Be aware that the percentage by type of water source was extrapolated according to the survey results of sample localities.

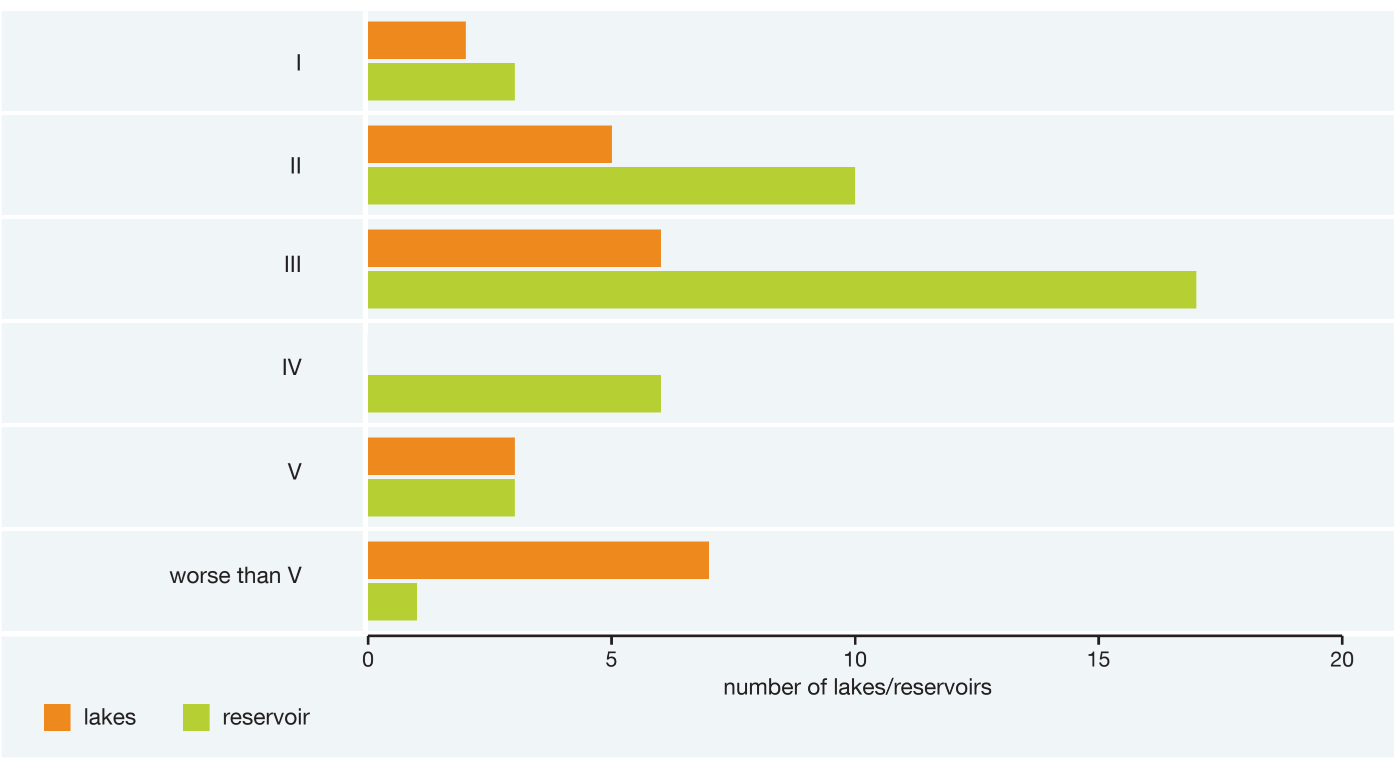
### 4.2.2 WATER QUALITY FROM PROVINCIAL LEVEL DATA

Poor sanitation has been recognized as an important factor for water body deterioration, and has received a high public profile for this reason. In the last two decades, rapid urbanization and population growth have together imposed tremendous pressures on the environment in Yunnan, and in particular on water resources. Many lakes and rivers have been degraded due to pollutants brought on by human activities. Domestic waste is the largest source contributing to water pollution. Despite increased investment in sanitation infrastructure and software development, the condition of most lakes and rivers in Yunnan have not been improved very much.

One example is Lake Dianchi, which used to be a clear lake and an important resource for drinking water, fishery, irrigation and recreation. However, largely due to a massive discharge of untreated wastewater, Lake Dianchi became so polluted that it is no longer suitable for drinking, thereby requiring high-cost water diversion works. Among the water supply projects, the largest one, the Zhengjiu water diversion and supply project alone cost four billion RMB (US$590 million). In addition, the fishery, irrigation and recreational functions of Lake Dianchi have been seriously affected. In Yunnan Province, other lakes, such as Xingyun and Qilu, face similar problems.

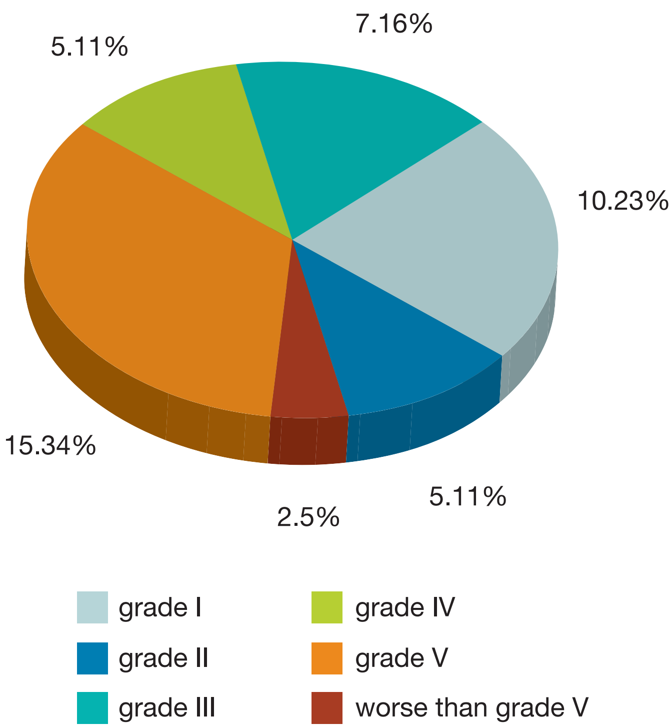
Among the 63 lakes and reservoirs in the province that have water quality monitoring, 68% have grade III or better water quality, 32% have water quality at grade IV, V or worse than V[29] (see Figure 14). The water quality of 40% of lakes and reservoirs satisfy their corresponding functional requirements, thus leaving 60% of water resources below the quality standards required for their current uses. Lakes close to the cities, such as Dianchi, Xingyun, Qilu and Yilong, are seriously polluted. For example, the permanganate index of many of these inland water resources is high, indicating strong contamination by oxidizable pollutants from agricultural, industrial and domestic sources. Dianchi, Yilong, Qilu and Xingyun Lakes suffer from severe eutrophication, caused largely by domestic wastewater and agricultural runoff. In 2008, 19,000 tons of ammonia-nitrogen

**FIGURE 14:** WATER QUALITY OF MAIN LAKES AND RESERVOIRS BY QUALITY CLASSIFICATIONS




[29] The surface water quality standard classifies surface water quality into five categories according to a set of indicators. Grade-I surface water is the best, suitable for drinking purposes, while Grade V is the worst, normally used for irrigation.

**FIGURE 15:** WATER QUALITY OF URBAN RIVER SECTIONS UNDER MONITORING




were released into lakes around Yunnan, of which 3,200 tons was industrial contribution (YEPD, 2009).

Nevertheless, due to the sustained efforts made in water pollution control since 2000, the pollution trend has been reversed. As illustrated in Figure 16, the number of key river sections with Grade-III or better water quality by 2008 has more than doubled since 1995. However, due to development activities, achieving full sanitation for the whole society and maintaining a healthy ecological environment remains a great challenge.

According to environmental statistics, in 2008 there were 552 million tons (equivalent to 1.34 million tons per day) of domestic wastewater produced, and the nitrogen discharged amounted to 1.58 thousand tons, and COD 187.8 thousand tons. Urban sewage (domestic wastewater plus rainwater) receiving treatment in 2008 was about 398 million tons, equivalent to a treatment rate of 72% of the total domestic wastewater generated (YEPD, 2009).

As seen in Figure 17, in the last ten years, the domestic wastewater treatment capacity has been tripled (YEPD,

**FIGURE 16:** EVOLUTION OF WATER QUALITY IN KEY RIVERS FROM 1995 TO 2008

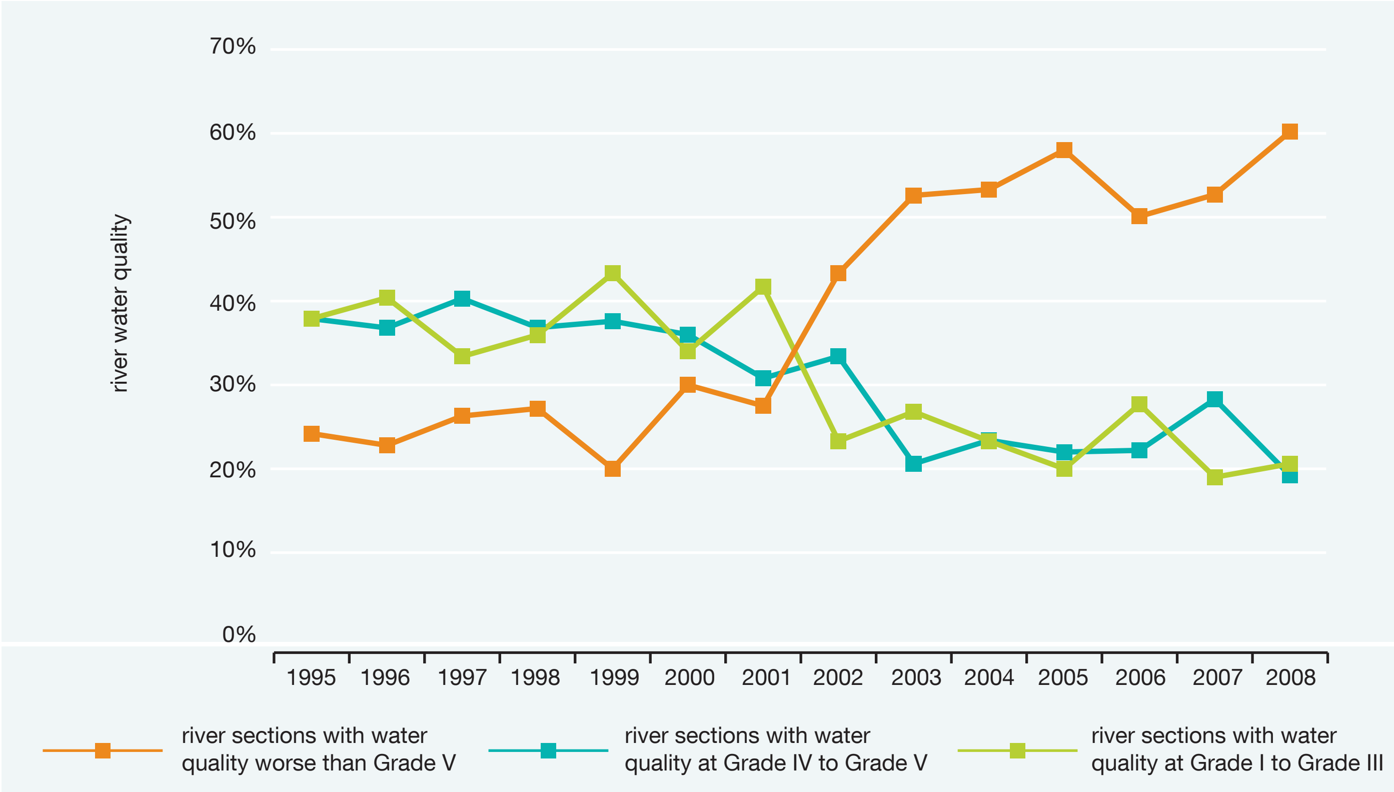
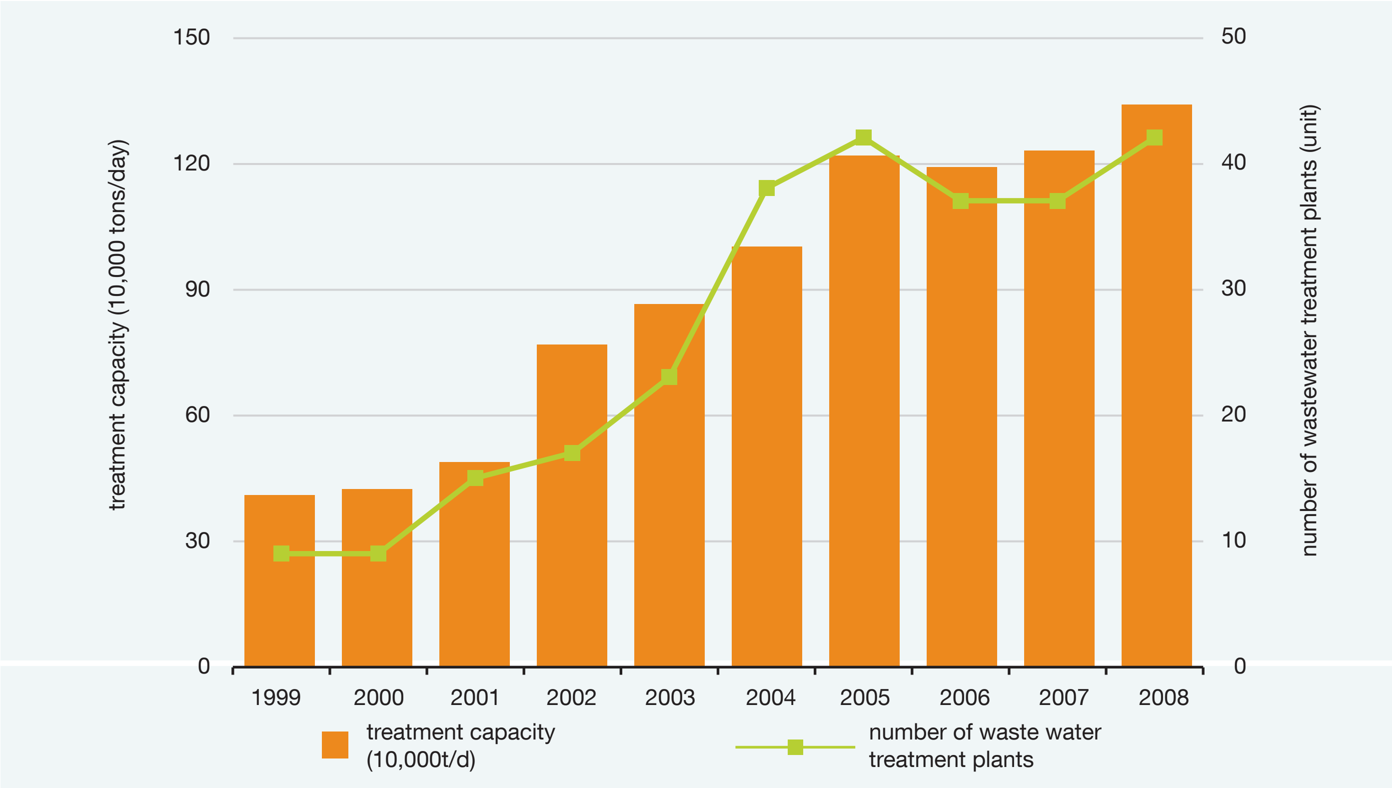


**FIGURE 17:** DEVELOPMENT IN WASTEWATER TREATMENT CAPACITY FROM 1999 TO 2008 (SOURCE: YEPD, 2009)




2009). And according to plans, by 2012 all of the 129 cities and county-level towns will be equipped with centralized domestic wastewater treatment plants (YHURDP, 2008).

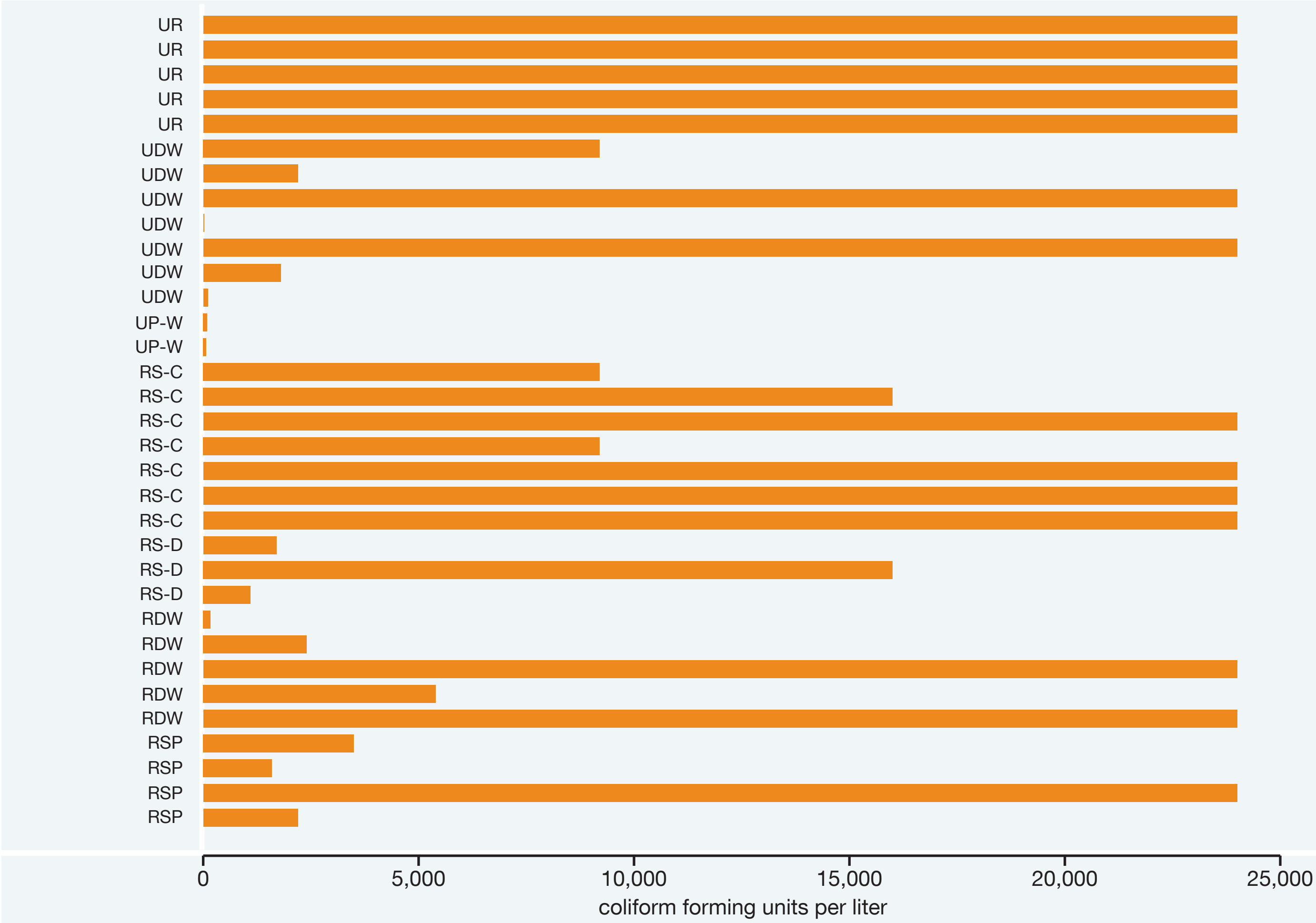
### 4.2.3 WATER QUALITY AND ITS DETERMINANTS AT STUDY SITES

The results of water quality measurements carried out in Qiubei town and villages are presented here. Full data tabulations can be found in Annex Table C 1. The results indicate that sewage in urban areas was transferred untreated to water courses, causing high levels of E.coli and the depletion of dissolved oxygen downstream. Similar problems were found in Xianrendong village, where intensive tourism activities, especially around the lake, are leading to the direct discharge of domestic wastewater to water bodies. When comparing the water quality measurement results in Qiubei county-town and Xianrendong where flush toilets are prevalent with that of other rural sites, pollution of the water bodies there was found to be even worse. E.coli, $NH_3$-N, TN and TP values of samples taken at the points where the sewage discharges into the water body are all very high, indicating a heavy influence of excreta from domestic sources. Related to that, their turbidity, conductivity, and COD values are also in the highest range. Although downstream results show a reduction in pollutants, environmental and health risks from human waste remains.

Drinking water quality in both urban areas and rural sites is poor, indicating a wide range of E.coli value. From the readings, it is difficult to correlate these readings with local sanitation practices. But a general trend does show that the mean $NH_3$-N value (0.002mg/l) of urban shallow well water is lower than the average of rural sites (0.004mg/l), which means human/animal waste has a more severe impact on the ground water in rural sites, which people reply on as a drinking water source. It can be concluded that rural people are more at risk for digestive infectious diseases due to unsafe water, and lower rates of centralized water treatment and distribution.

Besides the aforementioned reason, another factor might be that some dug wells are not protected/covered. In rural villages, household animal farming is a common practice, so the impact of animal waste on ground water might even be more serious in comparison to that of human waste, if animal waste is not properly handled.

**FIGURE 18:** E.COLI READINGS, BY WATER SAMPLING POINTS IN QIUBEI FIELD SITES




Key: UR - urban river; UDW - urban dug well; UP-W - urban piped from well; RS-C - rural surface water close to dwelling; RS-D - rural surface water distant from dwelling; RDW - rural dug well; RSP - rural spring water

To increase drinking water safety, sanitation improvement is essential and critical. However, when considering moving to a higher level up the sanitation ladder, safe disposal must be taken into account. Upgrading the physical structure alone will not help, unless human waste is treated and safely disposed of.

Not-isolated or partially isolated human excreta and household wastewater drain to ground are major determinants of water quality. Figure 19 shows the extent of isolation of human excreta and wastewater respectively. Full isolation normally is achieved through flush toilets connecting to sewage treatment, while partial isolation refers to dry pit, wet pit and other sanitation options requiring handling of waste by users. The extent of full isolation at all the field sites ranged from 49.1% to 89.7%, with an average of 66.4%. Among the eight different categories of three sites, the lowest percentage of not-isolated-sanitation of 0% was found at Dali urban site (U2) and the highest of 27.9% was found at rural Qiubei (R3). Even the improved latrine, in this case, water flush toilets, can cause serious pollution to the water body if the waste is not properly disposed of.

The field survey results suggest that the majority (67.4%) of surveyed households fully isolate their excreta, and that more households fully isolate their waste in urban areas than in rural or peri-urban areas. Unlike other sites, the percentage of open defecation in rural Qiubei (R3) is high (28%). And the second highest is found in the urban area of Qiubei (U3). Even in the urban sites where centralized wastewater treatment and septic tanks are placed, there are incomplete collecting systems and/or mixed rainwater and wastewater collecting systems.

**FIGURE 19:** EXTENT OF ISOLATION OF HUMAN EXCRETA IN FIELD SITES

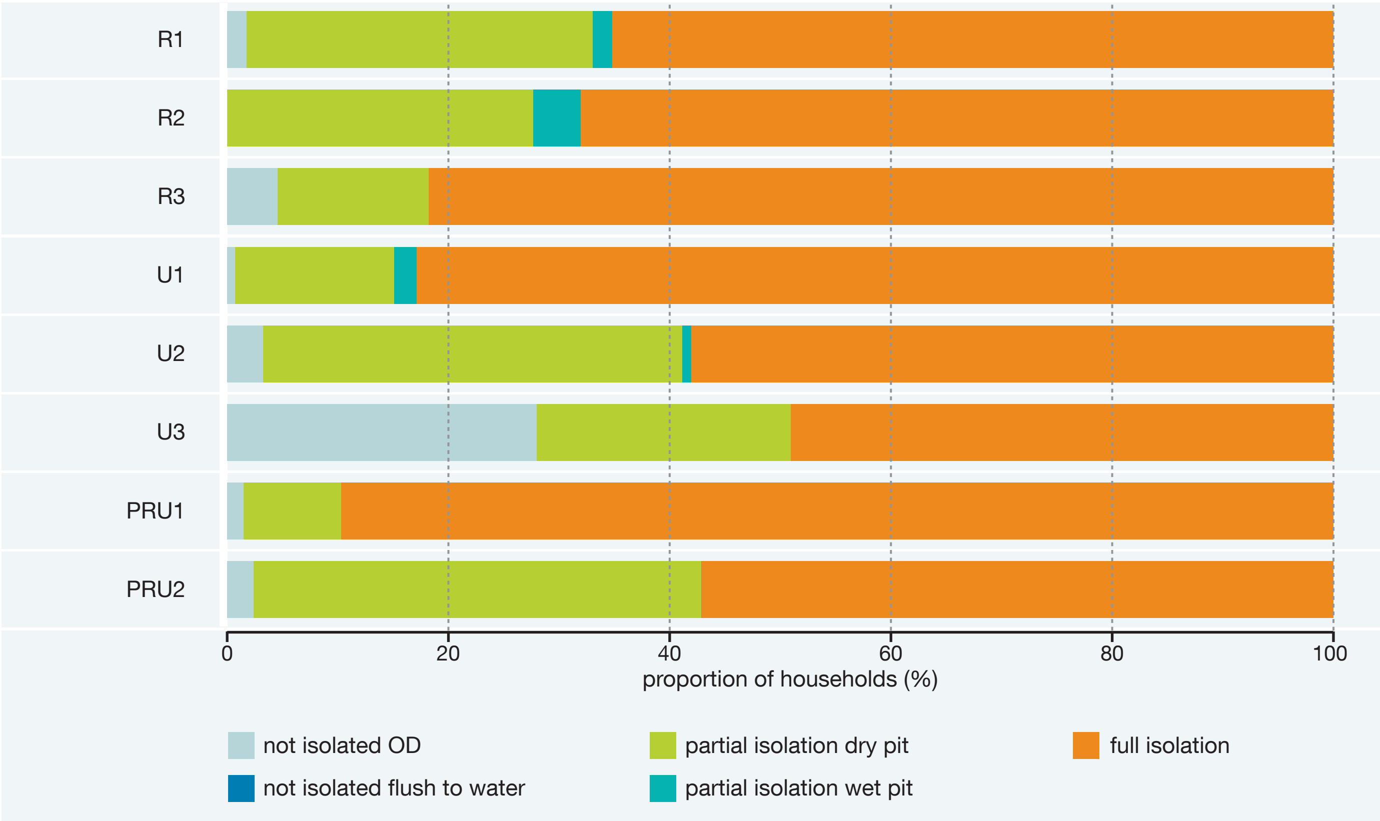
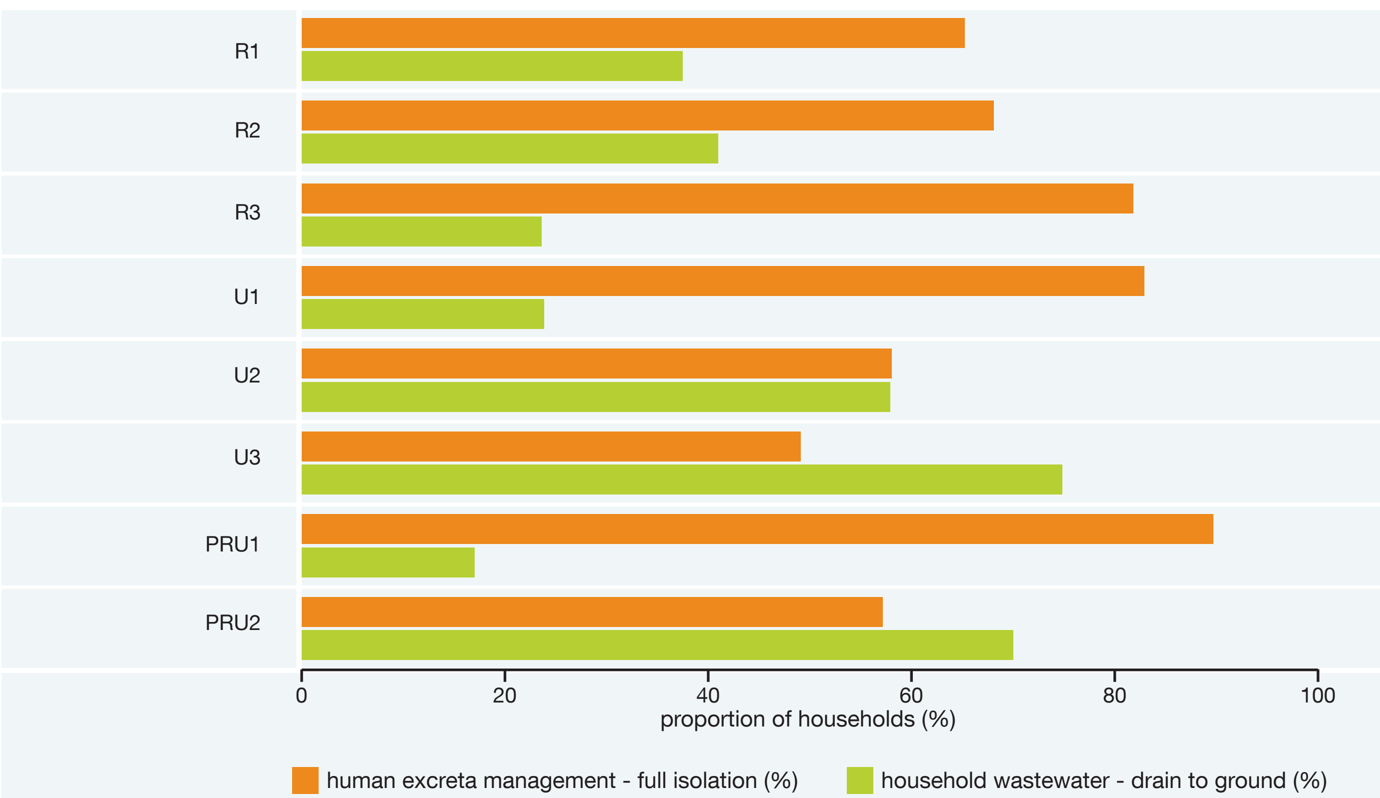



**FIGURE 20:** POLLUTION FROM POOR SANITATION AND WASTEWATER MANAGEMENT (% OF HOUSEHOLDS)



Draining household wastewater to the ground is very common at all rural, peri-urban or urban sites, and is practiced by an average of 43% of households investigated. In comparison to the rural sites (54%), the percentage in urban sites is much lower (34%). All the results from study sites revealed that more households are without household wastewater management than those without fully isolating sanitation facilities. Urban Qiubei has 82% of full isolation of waste but 75% of wastewater is discharged to ground, making it likely that contamination of human waste will take place downstream while in the rural areas with low isolation of human waste, the community's surroundings will be affected directly.

### 4.2.4 HOUSEHOLD WATER ACCESS AND TREATMENT COSTS

One of the major implications of polluted wells, springs, rivers and lakes is that households and/or water supply utilities will have to treat water, or treat water more intensively, for safe human use. Alternatively, households and water supply utilities can access cleaner water from different and more distant sources, thus increasing access costs. Those who do not take precautionary measures are exposed to a higher risk of infectious disease, or poisoning due to chemical content. Table 16 shows the percentages of households by different categories of primary sources for drinking water, and the average annual cost per household. Except in Qiubei, access to piped water with standardized or simple treatment is generally high in other rural, peri-urban and urban areas, ranging from 81% to 98%, while in rural Qiubei only 29% of households have access. One reason might lie in the rather high dependence on surface water as a drinking source there. More details can be found in Annex Table C 1.

Figure 21 shows the summary of householders' responses to the question on characteristics of poor quality water that they were using at the time of the survey. It seems that contamination of solids in the water is the general concern at all three sites. For piped water, users complained about the bad appearance, taste and dregs, while users of untreated or unprotected water complained about a bad smell and dregs. As shown in Table C5, there were more complaints from urban piped water users than rural and peri-urban users. However, in reality, the majority of the piped-water users are located in urban areas, so the complaints from those urban users are likely to be more than from rural sites. It cannot be concluded that the water quality of piped water in rural sites is better than that in urban sites. The cited bad taste or smell in piped water by the urban respondents may be related to the disinfectant agent used for centralized treatment. For non-piped (protected or unprotected) water, urban and peri-urban residents generally have higher hygiene awareness and are seeking better living standards than rural dwellers, which could also be one of the reasons to explain this phenomenon. The cited bad taste or smell in piped water by the urban respondents may be related to chlorine residue used for centralized treatment.

In dealing with polluted traditional water sources, households may react differently: purchasing bottled water, walking further to haul free water, having water treatment at home, connecting to a piped water source (if available and affordable), or harvesting rainwater.

Figure 22 shows that whether at rural, peri-urban or urban sites the users of all three water sources (piped water, non-piped protected source and non-piped and unprotected source) see water quality as the most important factor, then available quantity as the second most important, while cost is the least important factor for the respondents in deciding to use the current water source.

**TABLE 16:** WATER ACCESS AND TREATMENT COST FOR THREE CATEGORIES OF DRINKING WATER SOURCE

| Water source | Indicator | Rural sites | Urban sites | Peri-urban sites |
|---|---|---|---|---|
| Piped water | % access | 66% | 86% | 93% |
| | Average Annual Cost | US$29 | US$29 | US$52 |
| Non-piped protected | % access | 20% | 11% | 4% |
| | Average Annual Cost | US$34 | US$20 | US$16 |
| Unprotected | % access | 14% | 3% | 3% |
| | Average Annual Cost | US$11 | US$41 | US$32 |

**FIGURE 21:** HOUSEHOLDS CITING POOR WATER QUALITY FROM THEIR PRINCIPAL DRINKING WATER SOURCE

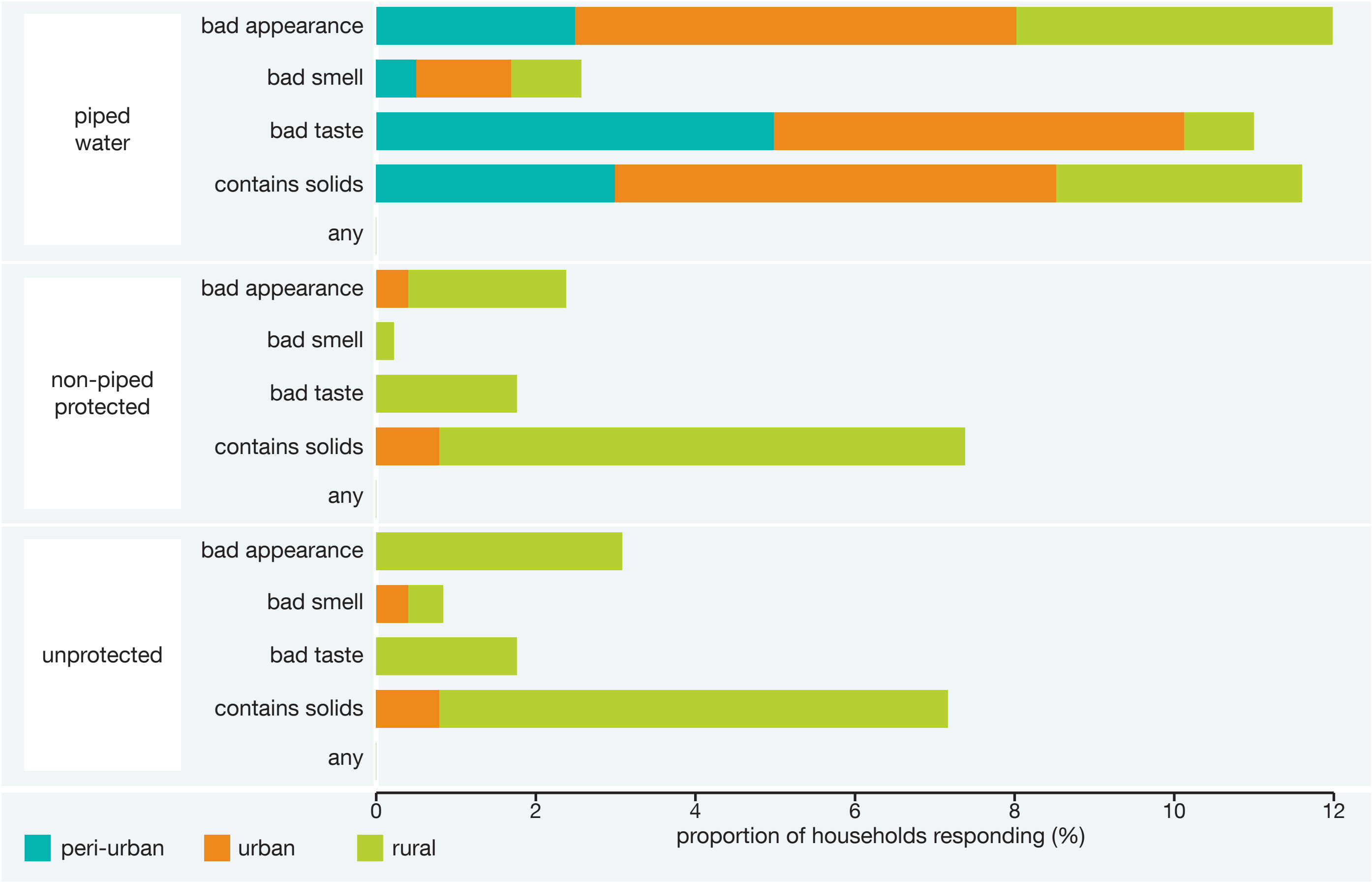
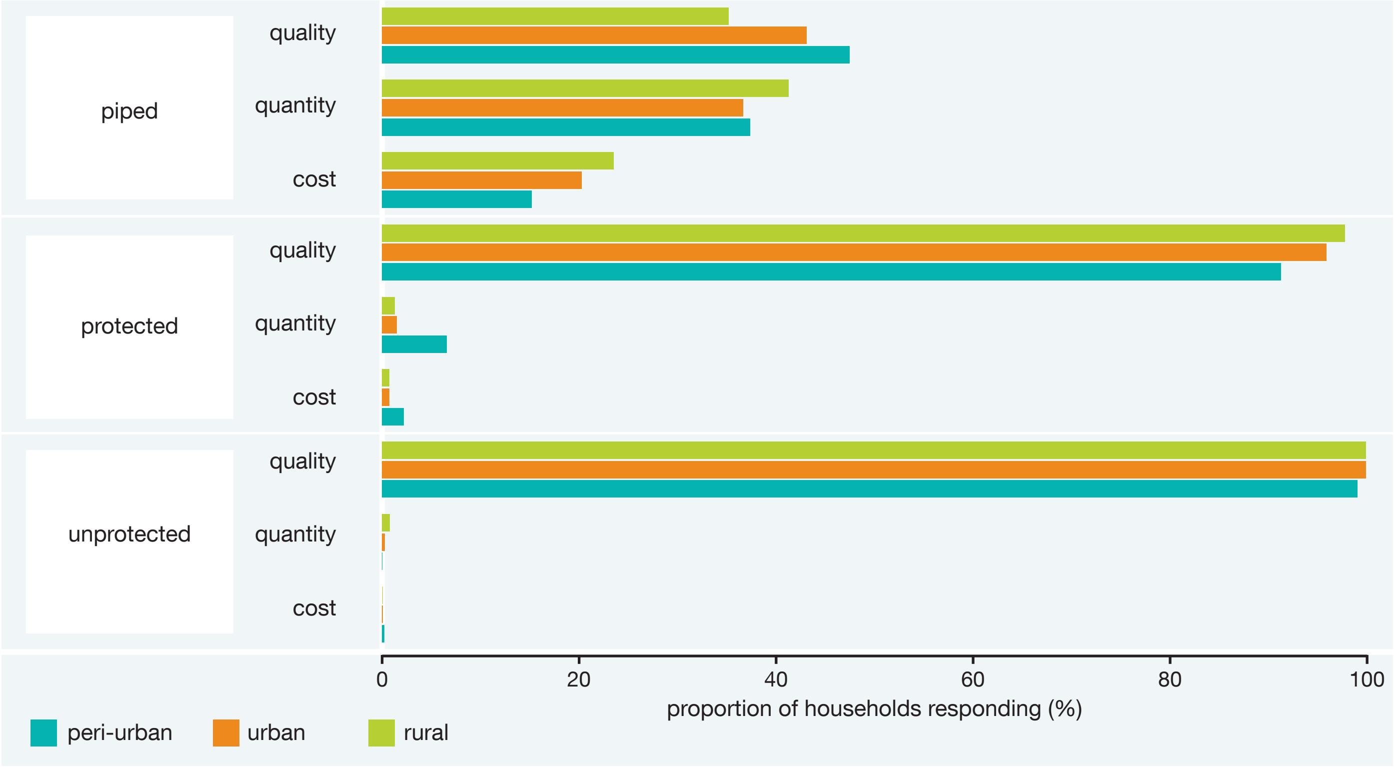



**FIGURE 22:** CITED REASONS FOR USING WATER SOURCES – RURAL VERSUS URBAN



They may change the source of hauled water, or introduce new sources (e.g. drill a household well or buy bottled water). In addition, as well as in isolation, they may treat water at home. Particularly in urban areas/cities, many households are sourcing their drinking water from bottled water or buying extra filters for home use.

As illustrated in Figure 23, when we look into the specific quality-related reasons for using the existing water source, generally those who have responded at all sites perceive that good taste and good color are mostly important, followed by a reduction in solids and being safer for health. The hygienic importance of water is apparently not well recognized by the users.

As seen in Figure 24, boiling is the dominant practice for treating water at home; only a few applied filtration or stand-and-settle, while many people do nothing to treat the water. Because boiling water for drinks is a common practice in China, it is impossible to separate the amount of water boiled for the purposes of killing bacteria. It is also hard to foresee whether this practice will be reduced once water quality is improved, based on the data collected from the field study.

**FIGURE 23:** CITED REASONS FOR USING WATER SOURCES

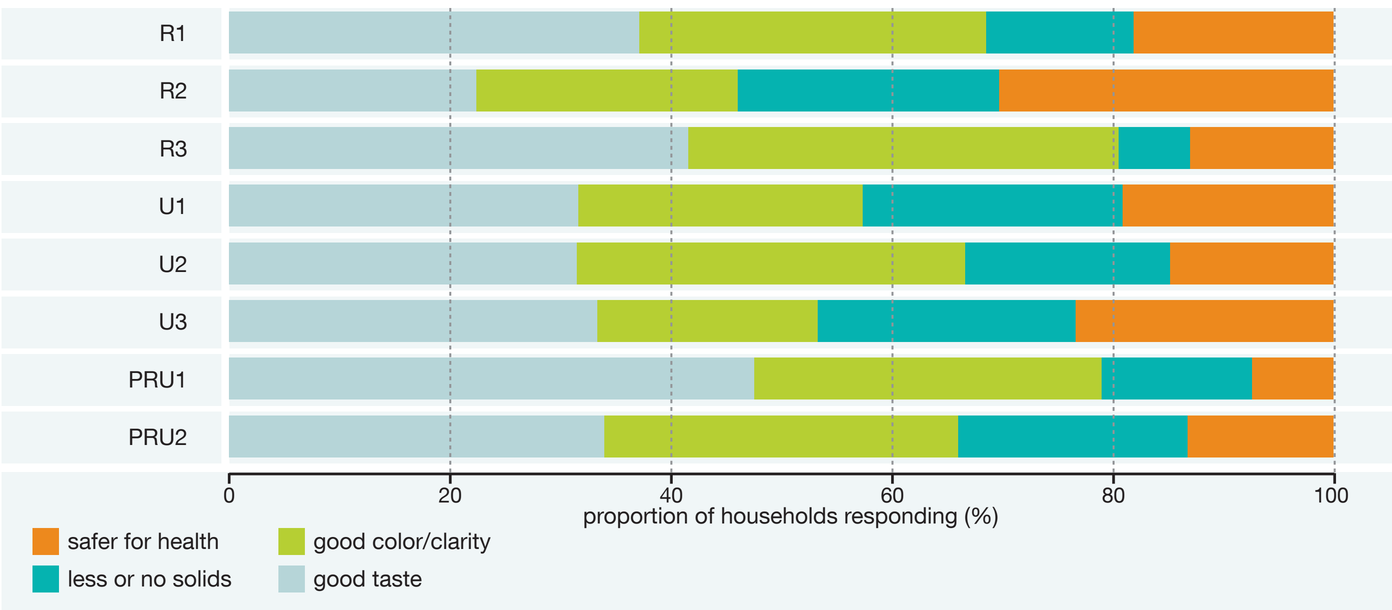



**FIGURE 24:** HOUSEHOLD WATER TREATMENT PRACTICES

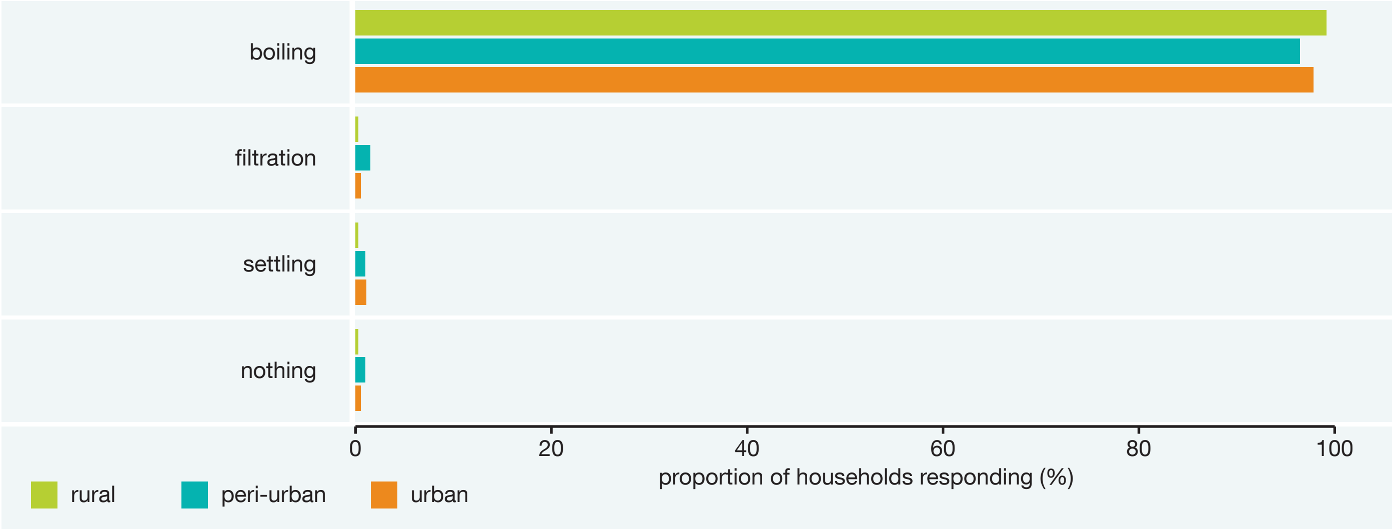


**TABLE 17:** WATER ACCESS AND HOUSEHOLD TREATMENT COSTS INCURRED AND AVERTED (US$, 2009)

| Variable | Annual average costs per household (US$) | | | Annual average costs averted per household following 100% sanitation coverage (US$) | | |
|---|---|---|---|---|---|---|
| | Rural | Peri-urban | Urban | Rural | Peri-urban | Urban |
| Water source access | 84 | 76 | 83 | 2.1 | 1.7 | 1.8 |
| Water treatment | 27 | 32 | 50 | 7.3 | 7.0 | 6.7 |

### 4.2.5 HOUSEHOLD WATER COSTS AVERTED FROM IMPROVED SANITATION

Table 17 shows that water access cost is roughly US$80 per household per year. Although in most rural villages water fees do not fully recover provision costs, as in most cases, customers do need to contribute to the construction and maintenance of the waterworks. In cities, where the cost of a centralized water supply is shared by a large population, the average cost per capita is lower than that in villages. Unlike the water source access cost, water treatment cost varies in these three types of areas, of which that of the peri-urban area is the highest.

Households with unsecured drinking water sources tend to buy bottled water, if it is available and affordable, or in most cases treat water at home by boiling, settling and decomposition and other means. Boiling is the most prevalent home treatment method, with an average cost of US$27 to US$50 per household depending on area. If water supply and sanitation are improved, for example, a well regulated piped water supply can provide pathogen-free water, then perhaps the household boiling will be reduced, despite the fact that the Chinese tradition of boiling water to make hot tea will remain the norm. As a result, household water treatment costs will only be partially averted, with cost reductions of an estimated US$7 per household per year.

For water source access costs, when water is sanitized by centralized water treatment, it can be done much more cheaply than household boiling. As Table 17 shows, annual average water treatment costs per household can be reduced dramatically following 100% sanitation coverage and change in household behavior.

## 4.3 ACCESS TIME

### 4.3.1 ACCESS TIME AND TIME SAVED

In Kunming, most urban households without their own toilets use public toilets nearby. In Dali, most people choose to defecate in a "neighbor's plot" or in their "own plot", indicating shared toilets and toilets outside houses are popular there. However, in Qiubei, most men and women choose their "neighbor's plot" or an "outside plot", showing shared toilets and public toilets are relatively popular there.

In rural areas, most peasants from Luquan, Kunming choose to use their "own plot", with average value close to 90%, while peasants (male and female adults ) from Dali and Qiubei prefer to use their "own plot", with an average value greater than 90%. One-hundred percent of rural children choose to use a "neighbor's plot."

Over 70% of male and female adults on the urban-rural fringe choose to use an "outside plot", while the rest use their "own plot". Almost every child has made the same option with some tiny differences. One-hundred percent of rural children in Jinning (site PU1) choose to use an "outside plot" and 75% of rural children in suburban Dali choose to use an "outside plot", with 25% using the other two options.

For the households with no own toilet, it is normal to make a round trip from home to toilet several times a day. However, no previous research has ever calculated how much time they spend on this. The data can provide much useful information directly or indirectly for researchers, such as land utilization, community scale, situation of local health development, etc. So far, no research has been made on this subject. Therefore, studies and data of ESI projects may fill the gap. Access time includes urination and defecation and the same travel time is assumed for each. Figure 26 shows average time per trip and waiting times per day spent accessing toilets for those with no toilet in different sites.

The following conclusion is drawn by means of data analysis of different groups in three different sites: On average, in Yunnan, rural women go to the toilet 4.2 times a day and spend 6.3 minutes per time, urban women go 4 times a day and 3 minutes per time, and suburban women 4 times a day and 4 minutes per time. The figures for rural women, urban women and peri-urban women are the same as those for rural men, urban men and peri-urban men. On average, rural children go to the toilet 6 times a day and spend 8.4 minutes per time, urban children go 4.7 times a day and 5.8 minutes per time, and peri-urban children 5 times a day and 9.6 minutes per time.

### 4.3.2 PREFERENCE FOR TIME SAVING AND UNIT VALUE OF TIME

When the households with no own toilets choose a toilet type or make decisions for getting/building a toilet, the most important determinant for 50% of rural households and 75% of suburban households is to save time. All the interviewed urban households in Qiubei agree on "proximity/distance" as the most important reason for them to get/build a toilet. Furthermore, 73% of rural households also consider time saving as the top reason to get a toilet.

Among the households with their own toilets, 54% of rural interviewees, 62% of urban interviewees and 56% of suburban interviewees are satisfied with locations of toilets (distance). The overwhelming majority (over 98%) of households without their own toilets are not satisfied with locations of toilets.

**FIGURE 25:** PLACES OF DEFECATION FOR HOUSEHOLDS WITH NO "OWN" TOILET (%)

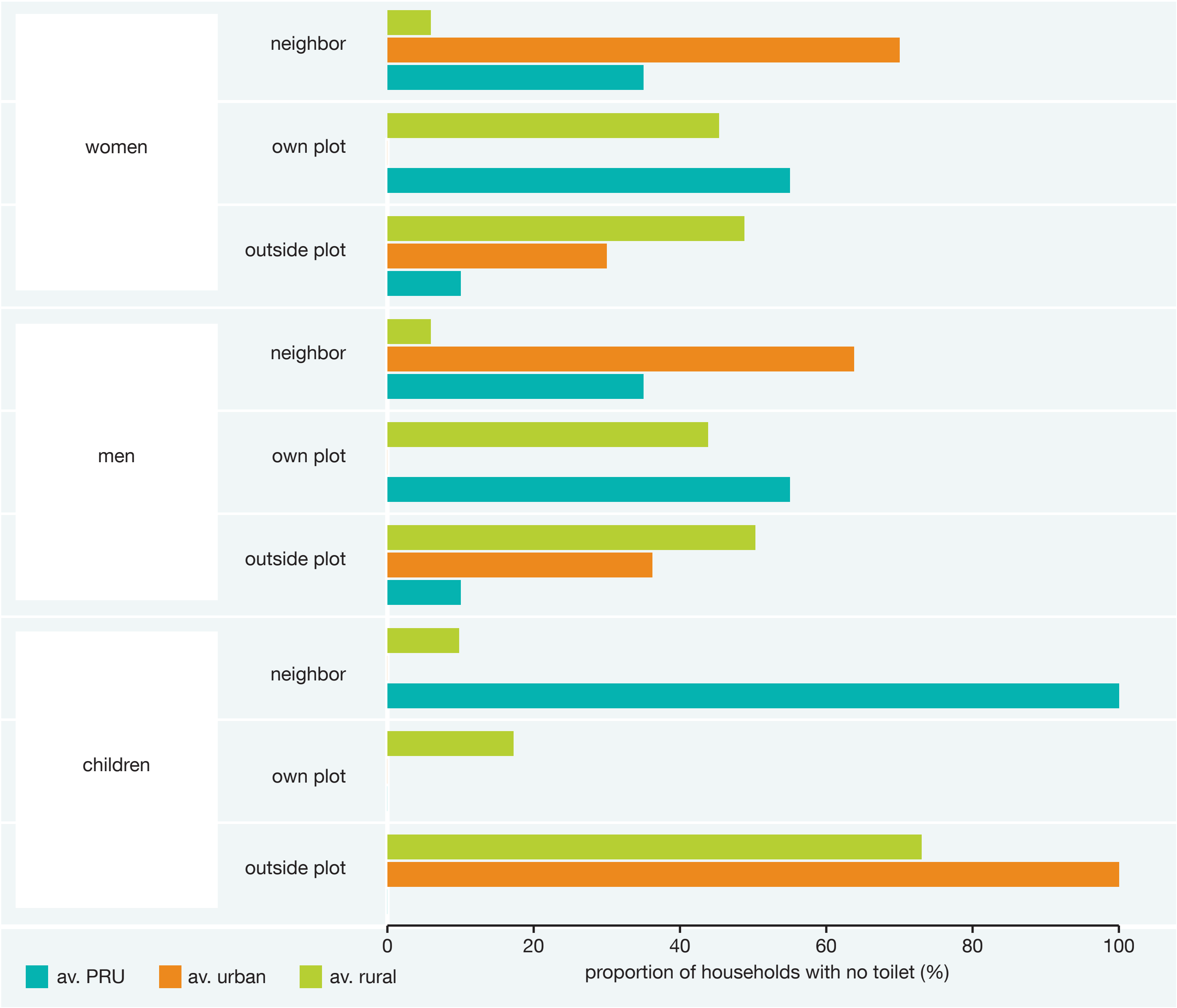


**FIGURE 26:** AVERAGE TIME PER TRIP AND WAITING TIMES PER DAY SPENT ACCESSING TOILET FOR THOSE WITH NO TOILET IN DIFFERENT SITES

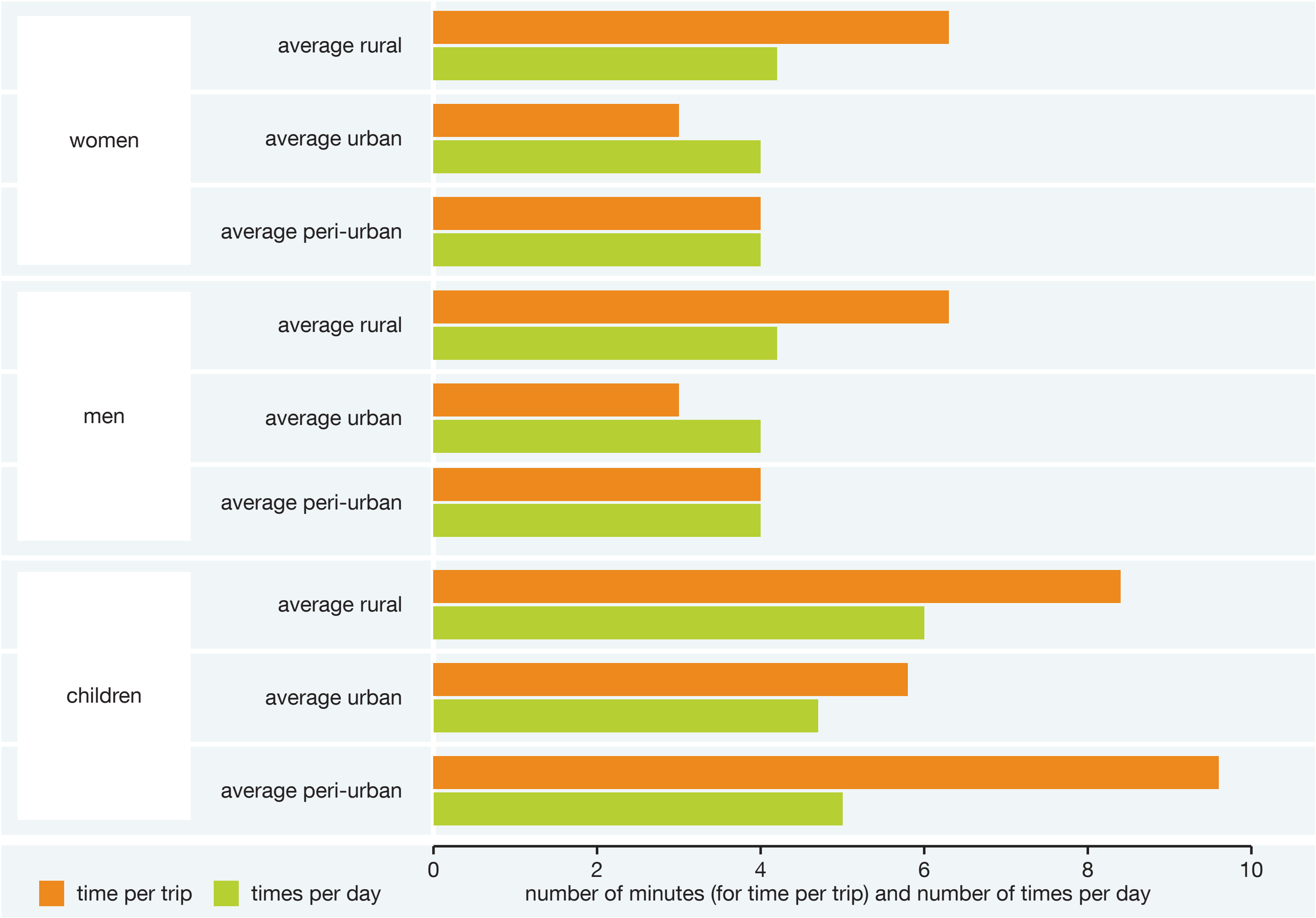
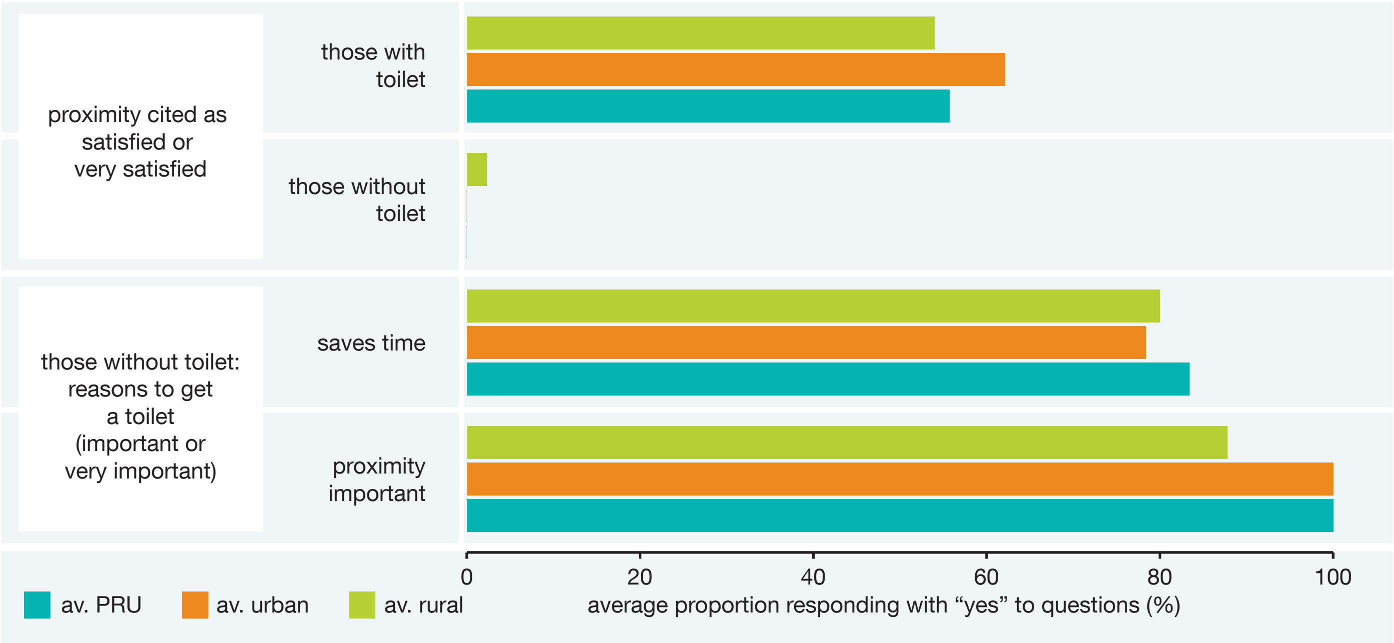



**FIGURE 27:** AVERAGE CITED PREFERENCES IN DIFFERENT SITES (%)



Saving time is a major reason as a household decides to build a toilet. Therefore, distance is crucial. On average, 80% of rural households, 78% of peri-urban households and 83% of urban households agree that saving time is an important reason. All the interviewed urban and peri-urban households agree on "proximity/distance" as one of the reasons for them to get/build a toilet. Furthermore, 88% of rural households agree with this viewpoint.

Analysis on results of the group discussion has supported results of door-to-door questionnaire interviews.

Findings from the focus group discussion on the satisfaction with toilet convenience in different sites are summarized in Table 18.

Most urban households with flush toilets are satisfied with convenience and time saving of private flush toilets. The tenants and the residents in urban areas who use public toilets complain about time wasted in using public toilets and the inconvenience. In peri-urban areas, households that use public toilets have reflected difficulties and problems concerning convenience and time saving. The poor quality of toilets is perceived to be an issue by peri-urban dwellers. Most rural villagers with their own toilets, especially those with 3-in-1 biogas units, are very satisfied with convenience of toilets. They consider that 3-in-1 biogas units not only are safe and convenient, but also can protect the environment, improve sanitary conditions and save time, energy and labor. Villagers that use public toilets are not so satisfied. They wish to improve their own living circumstances and enhance their quality of life.

Men and women hold different attitudes toward convenience and time saving of toilets. Women are more concerned about, and sensitive to safety, privacy and convenience of toilets than men, especially the women without their own toilets. Urban women think about safety, convenience and time of toilets when going out (for business trips, travel etc), while rural women pay special attention to a type of a toilet from which more manure can be obtained, besides safety, convenience and time of toilets.

According to results of the group discussion, generally, if 30 minutes can be saved per day, 70% of men will spend it on rest and recreation, 20% on economic activities and

**TABLE 18:** PROPORTION OF POPULATION SATISFIED WITH TOILET CONVENIENCE

| Site | Type of Toilet (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flush toilet | | | 3-in-1 biogas unit | | | UDDT | | | Improved pit-latrine | | |
| | Men | Women | All | Men | Women | All | Men | Women | All | Men | Women | All |
| Rural | 22 | 24 | 46 | 24 | 24 | 48 | 10 | 10 | 20 | 30 | 30 | 60 |
| Urban | 20 | 25 | 45 | 0 | 0 | 0 | 2 | 3 | 5 | 0 | 0 | 0 |
| Peri-urban | 8 | 10 | 18 | 2 | 3 | 5 | 6 | 6 | 12 | 18 | 17 | 35 |

**TABLE 19:** OPPORTUNITY COST OF TIME – HOW MANY RESPONDENTS WOULD SPEND AN EXTRA 30 MINUTES A DAY DOING DIFFERENT ACTIVITIES (%)

| Ranking | Respondents with toilet (% ) | Respondents with no toilet (% ) |
|---|---|---|
| | RURAL SITES | |
| Ranking 1 | Leisure 34.5% | Work/help to generate income/output/economic practice - 5.7% |
| Ranking 2 | Work/help to generate income/output/economic practice - 31.0% | Leisure - 2.0% |
| Ranking 3 | Cleaning room, washing clothes, cleaning yard - 21.5% | Sleeping - 1.5% |
| | URBAN SITES | |
| Ranking 1 | Leisure 41.5% | Leisure - 1.2% |
| Ranking 2 | Cleaning room, washing clothes, cleaning yard - 19.4% | Work/help to generate income/output/economic practice - 0.8% |
| Ranking 3 | Sleeping - 17.0% | Cleaning room, washing clothes, cleaning yard - 0.8% |

10% on cleaning (rooms, clothes and courtyard etc). Sixty percent of women will spend it on cleaning (rooms, clothes and courtyard etc), 30% on production and economic activities and 10% on rest and recreation. Men and women differ in how they allocate and use the extra 30 minutes. The overwhelming majority of women would like to spend it on house cleaning. Therefore, women should be the main target group of environmental and sanitary infrastructure construction projects. Women's involvement in planning, design, implementation and monitoring of environmental and sanitary infrastructure promotion projects is an essential element to improve project benefits and realize the sustainability of projects and social development.

### 4.3.3 TOTAL VALUE OF SAVED TIME

Saved time is different between urban and rural areas due to locations of toilets. Figure 28 shows the average time saved per year per household member.

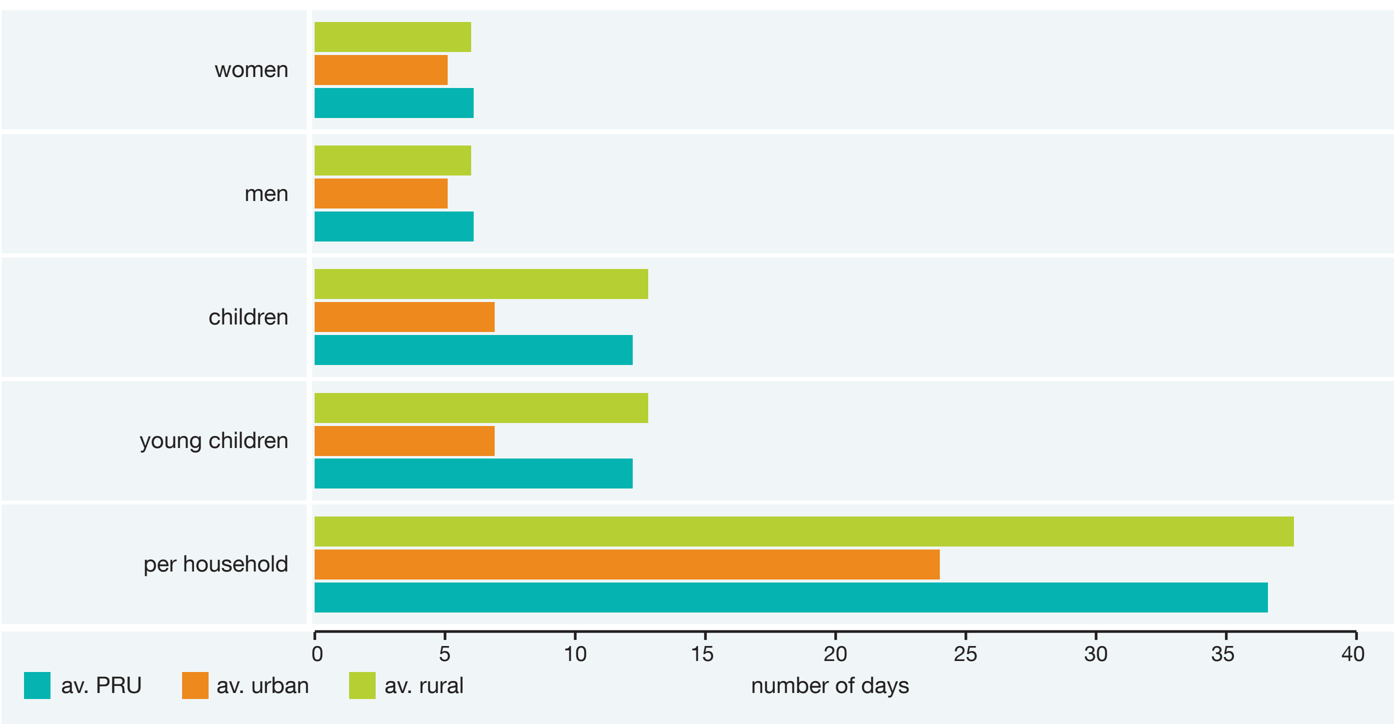
The average data of Yunnan Province is obtained by means of the summarization of data in three different sites. In rural areas, the average time saved per year for women and men is six days, children 12.8 days and each rural household 37.6 days. In urban areas, the average time saved per year for women and men is 5.1 days, children 6.9 days, adults that accompany children 6.9 days and each urban household 24.0 days. In peri-urban areas, the average time saved per year for women and men is 6.1 days, children 12.2 days and each peri-urban household 36.6 days.

Average time value per year saved by each household member is shown in Figure 29. For the opportunity cost for access to toilets, 30% of hourly wage for adults and 15% for children are assumed in this study. Working days per year is 230 days for the daily rate calculation of the average wage in the different sites. The average annual value of time savings per household in rural sites is 298 yuan, 410 yuan in urban sites, and 439 yuan in peri-urban sites.

## 4.4 REUSE OF HUMAN EXCRETA

Data in Table 20 show reuse of human excrement of households with different types of toilets in different sites. Among the interviewed households with unimproved toilets, 56 households defecate outdoors, accounting for 6.3% of the total number of households. One hundred and eighteen households use shared toilets, 14.5% of the total, and 13.6% of the 118 households reuse excreta. Although excreta is reused from pit latrines, it is not included in the CBA calculations as this reuse is not safe.

**FIGURE 28:** AVERAGE TIME SAVED PER YEAR PER HOUSEHOLD MEMBER (DAYS)




Source:Annex tabel D

**FIGURE 29:** AVERAGE ANNUAL VALUE OF TIME SAVINGS PER HOUSEHOLD (US$, 2009)

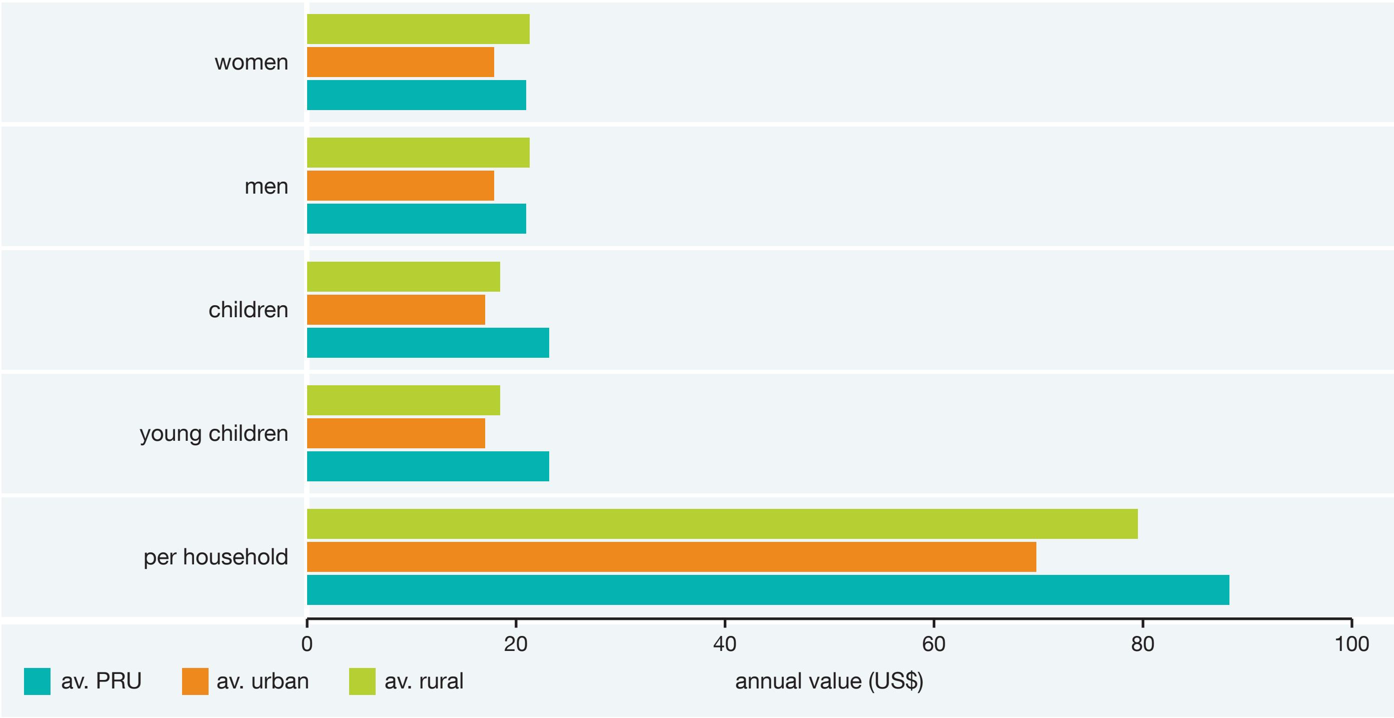



**TABLE 20:** SANITATION COVERAGE AND HOUSEHOLDS REUSING EXCRETA IN EIGHT DIFFERENT FIELD SITES

| Field sites | Number of households | % | Of which reuse (%) |
|---|---|---|---|
| UNIMPROVED | | | |
| OD | 51 | 6.3 | 0 |
| Private pit | 2 | 0.2 | 0 |
| Shared | 118 | 14.5 | 13.6 |
| IMPROVED | | | |
| Simple pit | 174 | 21.4 | 33.0 |
| Wet pit | 276 | 34.0 | 23.2 |
| UDDT | 67 | 8.3 | 40.3 |
| Biogas | 56 | 6.9 | 19.6 |
| Septic tank | 68 | 8.4 | 0 |

Among the interviewed households with improved toilets, 174 households use single-pit latrines, 21.4% of the total number of households, and 33% of them reuse the single-pit latrines. Two hundred and seventy six households use wet pit latrines, 34% of the total, and 23.2% of them reuse the waste from wet pit latrines. Sixty seven households use UDDTs, 8.3% of the total, and 40.3% of them reuse the UDDTs. Fifty six households use 3-in-1 biogas units, 6.9% of the total, and 19.63% of them reuse the 3-in-1 biogas units. Sixty eight households use flush toilets (connected to septic tank and sewerage), 8.4% of the total, and none of them reuse the waste from flush toilets.

The results of a group discussion concerning safety for reuse of human excrement show that over 98% of people think flush toilets connected to septic tank and sewerage is safe, sanitary and environmentally friendly. Of the options, the perceived safety (in descending order of safety) is as follows: flush toilet, improved pit latrine, unimproved outdoor pit latrine, pail-closet, digging a hole, and open defecation.

**TABLE 21:** VALUE ASSOCIATED WITH REUSE OF HUMAN EXCRETA (US$, 2009)

| Variable | % households | | Average value (US$) |
|---|---|---|---|
| | Own use | Selling | Own use |
| Composting (fertilizer) | 100 | 0 | 46.8 |
| Biogas generation (with animal excreta) | 100 | 0 | 77.3 |

**TABLE 22:** RESPONDENTS' UNDERSTANDING OF SANITATION (THE TOP THREE ANSWERS)

| | Household interview | Focus Group Discussions | | | |
|---|---|---|---|---|---|
| | | With sanitation | | Without sanitation | |
| | | Men | Women | Men | Women |
| **Average rural** | 1. flush toilet connected to sewerage 17%<br>2. private toilet 7%<br>3. toilet built in yard or near the residence 4% | 1. improved pit-latrine 18.3%<br>2. 3-in-1 biogas unit 11.3%<br>3. UDDT 10% | 1. improved pit-latrine 19.7%<br>2. 3-in-1 biogas unit 18.6%<br>3. UDDT 10.3% | 1. shared toilet 4.3%<br>2. improved pit latrine 3%<br>3. flush toilet with septic tank or sewerage 1.3% | 1. shared toilet 5.7%<br>2. improved pit latrine 3.3%<br>3. UDDT 0.7% |
| **Average urban** | 1. flush toilet connected to sewerage 6%<br>2. improved public toilet 2.3%<br>3. toilet building near the yard or house 1.7% | 1. flush toilet (connected to septic tank and sewerage) 20.3%<br>2. public toilet 7.3%<br>3. improved pit-latrine 1.7% . | 1. flush toilet connected to septic tank and sewerage 26.7%<br>2. public toilet 8.7%<br>3. improved pit latrine 6.3% | 1. flush toilet connected to septic tank and sewerage 22.7%<br>2. public toilet 9.7%<br>3. improved pit-latrine7.3% | 1. flush toilet connected to septic tank and sewerage 27.6%<br>2. public toilet 10%<br>3. flush toilet 10.3% |
| **Average Peri-urban** | 1. improved flush toilet 9%<br>2. improved public toilet 6.5%<br>3. toilet installed in the house 5% | 1. flush toilet connected to septic tank and sewerage 20%<br>2. public flush toilet 10%<br>3. UDDT 4% | 1. flush toilet connected to septic tank and sewerage 19%<br>2. public flush toilet 12%<br>3. UDDT 5.5%<br>4. 3-in-1 biogas unit 5.5% | 1. flush toilet connected to septic tank and sewerage 19%<br>2. public flush toilet 10%<br>3. UDDT 4% | 1. flush toilet connected to septic tank 22%<br>2. public flush toilet 11.5%<br>3. UDD 10% |

Table 21 shows analysis on values of reuse of human excrement. According to the table, 219 households use compost only for private use. Since total money saved from the use of compost is RMB70,109 yuan, it is RMB320 yuan for each household. There are 34 households using 3-in-1 biogas units. Since total money for energy saving is RMB17,960 yuan, it is RMB528 yuan for each household. The unsafe handling of excreta may result in having health costs. Therefore, the value of excreta use from pit latrines is not included in the CBA. Only the value of reuse from UDDTs and biogas is included.

## 4.5 INTANGIBLE SANITATION PREFERENCES

Over 100 people participated in a total of 24 focus group discussions (FGDs), of whom 60% were women. Findings were compared between groups consisting of women's and men's groups, between households with improved and unimproved sanitation, and between rural, urban and peri-urban sites. The topics covered in the FGDs included understanding of sanitation and attitudes to school and workplace sanitation, factors explaining current sanitation, satisfaction with current sanitation options and worries of people without sanitation options on the dangers of open defecation, preferences for sanitation options, and decision making on sanitation choices. Data from the household survey are also used to cross check with the FGD findings.

### 4.5.1 UNDERSTANDING OF SANITATION AND ATTITUDES TO SCHOOL AND WORKPLACE SANITATION

According to FGD results, most people's understanding of sanitation reflects the sanitation devices, location, and household and community waste treatment facilities, shown in Table 22. Sanitation should include improved toilet bowls located in houses, or nearby yards. Septic tanks or pits and public toilets must be non-leaking. In rural areas, the household survey shows that the most preferable sanitation option is flush toilets with sewerage, while the FGD shows that men and women with sanitation generally prefer improved pit-latrines.

The FGDs also investigated the experience of public toilets and institutional sanitation in work places. Most of the respondents thought that public toilets were very important except that a few rural villagers were less concerned about public toilets. Table 23 shows an example of the perceived importance of school, work place and public toilets in an urban area.

### 4.5.2 WHAT FACTORS EXPLAIN CURRENT SANITATION OPTIONS?

In urban sites, it is usual for urban households to be equipped with either an indoor private flush toilet built indoors or a public flush toilet connected to either a septic tank or sewerage. Most urban households do not change their toilets. All apartments are installed with flush toilets equipped with cheap devices by the property developer. In the case of new apartments, the first owner may be given the choice of bathroom hardware to install. At present, most apartments are only installed with washroom trunks connected to a septic tank and sewerage system, so the

**TABLE 23:** PERCEPTION OF THE URBAN POPULATION TOWARDS INSTITUTIONAL TOILETS - LIANGYUAN COMMUNITY, KUNMING CITY

| | |
|---|---|
| What is the perceived importance of toilets in school? Why? | Very important! Children spend quite a long time in school, which is vital for their futures. It saves time and is also safe. The school should build more toilets with larger spaces and that are of better quality. |
| What is the perceived importance of toilets in the working area? Why? | It is convenient for our work! We can save time, and work more efficiently. This is one of the reflections of a people-centered policy. |
| What is the perceived importance of toilets in public places? Why? | Public toilets can protect the environment, provide convenience to the people. They are beneficial in controlling transmission of diseases. |
| What is the perceived importance of well protection? | It is important to protect wells in order to prevent disease |

**BOX 1.** CASE STUDIES OF HOUSEHOLDS WITH NO TOILETS

**Dali Old Town: Lack of adequate land space for sanitation options**

Dali Old Town, with its Bai ethnic population and unique architecture and culture, is a famous tourism attraction. It has been rebuilt on the site of the previous old town with a municipal sewerage system connected to a wastewater treatment plant. But there are some residents using public toilets due to a lack of private sanitation options.

A lack of a proper land area to build private toilets is one of the main reasons that some households living in old communities of Dali Old Town do not have private toilets. If a household wants to build a toilet, he or she first has to build a private septic tank to connect to the municipal sewerage system. Therefore, the cost is very high. On the other hand, to protect the architectural style in the old town, private construction permits are strictly controlled.

**Xiangshui Miao ethnic village: Sanitation in a poor, disadvantaged, and difficult to access village**

Xiangshui Miao ethnic village, located in Qiubei County, is difficult to access from the town center. As of 2008, the village had 75 households, with an estimated 400 people. The village is poverty-stricken with poor physical infrastructure and living conditions. The average annual net income per capita of the village is less than RMB500.

For drinking water and domestic use water, the villagers have to fetch water from the hill gully by oxcarts or manual labor. There are only two shared pit latrines in the village constructed by the school and by a relatively wealthy household. It is the poverty and the lack of development opportunities that are the main reasons for not having toilets.

**The radical behavior changes required by UDDT results in low acceptance**

The village of Huichangcun, located on the banks of Dianchi Lake within Jingning County territory, has built UDDTs with government subsidies, but only around 20% were actually used. The reasons for the low acceptance of UDDT are mainly because of their poor quality and the need for dramatic change in the living habits. In addition, the project performance — such as lack of sufficient promotion of users' awareness on the new sanitation options and their functions — is also a main factor in affecting users' acceptance.

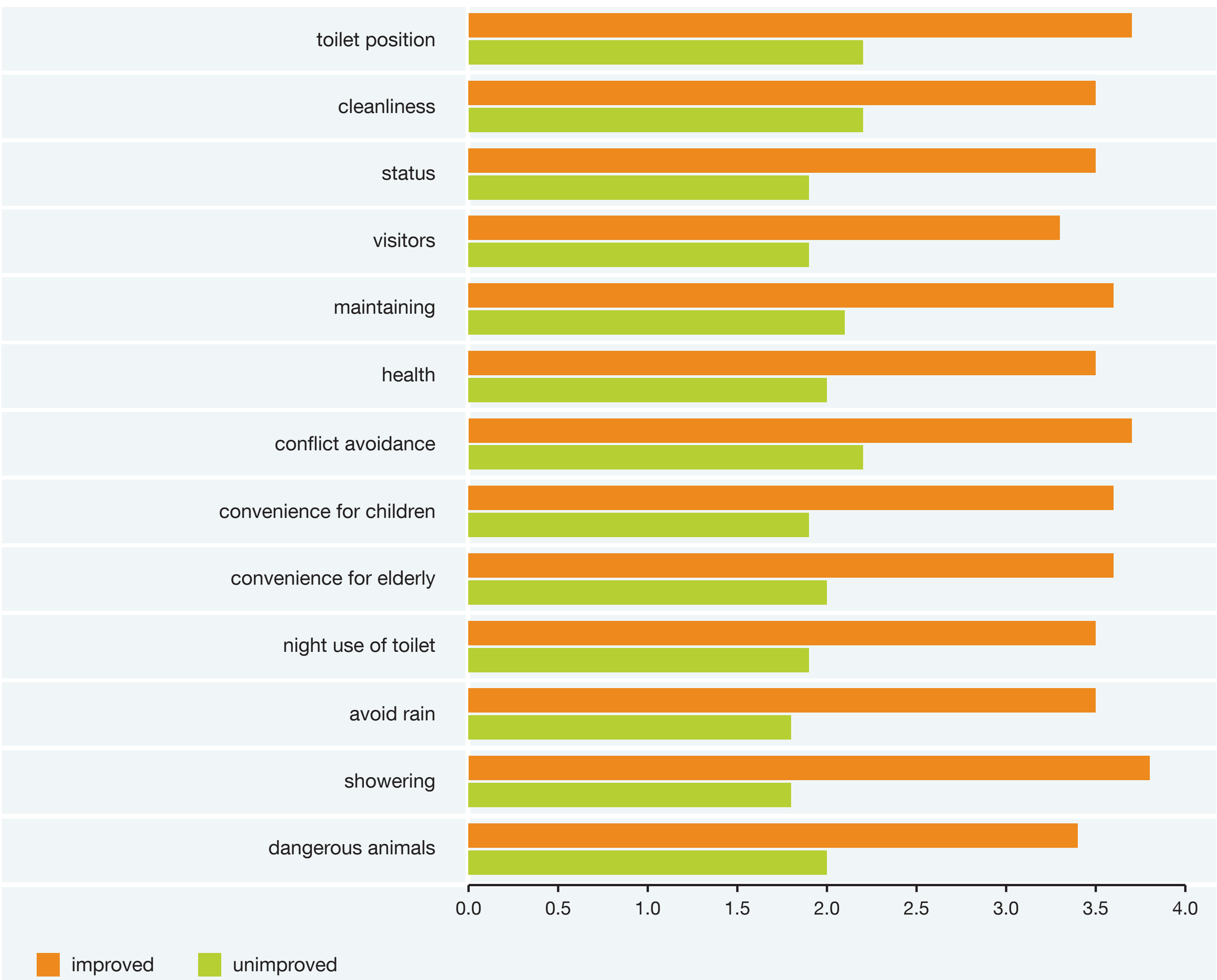
owners of apartments could choose different kinds of sanitation furnishings and options according to their preferences and the affordability of the sanitation options.

Across the peri-urban and rural sites, the households mostly use traditional pit latrines and shared pit latrines that are built outdoors and in communal places. In addition, 3-in-1 biogas units and UDDT are also used widely due to the promotion of governmental projects and other donors. A lack of a public sewerage system is the main constraint for the peri-urban and rural population in choosing flush toilets.

The main reasons why some households lack toilets include a lack of investment capital, a lack of a proper land site for construction, resistance to changing habits related to toilet-going and the required maintenance of new sanitation options. The two cases in Box 1 serve as examples of why households lack private sanitation options.

Also, the FGDs revealed that some male villagers have poor awareness of the importance of toilets and sanitation. The men claimed it is convenient to defecate in the open, because they do not need a fixed location and they feel unrestricted. What they need is a relatively concealed place. Furthermore, they do not have to clean the place up. Therefore, cropland, bushes, the place beside a ditch and even spaces in front of and in back of a house are used for urinating or defecating.

**FIGURE 30:** AVERAGE LEVEL OF SATISFACTION WITH CURRENT TOILET OPTION (1 = NOT SATISFIED; 5 = VERY SATISFIED)



### 4.5.3 SATISFACTION WITH CURRENT TOILET OPTION AND CONCERN OF PEOPLE WITHOUT TOILET OF DANGER OF OPEN DEFECATION

Figure 30 shows 13 indicators for household satisfaction towards current toilet options: toilet position, cleanliness, status, visitors, maintaining, health, conflict, convenience for children, convenience for elders, night use of toilet, avoiding rain, showering and dangerous animals. Across the 13 indicators, households with improved sanitation scored on average 3.5 in satisfaction, while households without improved sanitation scored 1.5 points lower, at 2.0.

Group discussions on satisfaction with use of toilets has supported the results of the above analysis from the ESI household interviews. When considered overall, the accumulated opportunity cost is high.

In the discussions, one sanitation option – the UDDT – did not fare as well as the other conventional options. Use of UDDT has failed to achieve the anticipated goal due to dissatisfaction with this option, such as low quality building materials and poor construction. Doors of some UDDTs have been broken before they are put to use. It is hard to change traditional toilet habits of users, so maintenance is not carried out and UDDTs are often not used appropriately. In short, the usage rate of UDDTs in many places is low. Some UDDTs have been turned into the villagers' "storehouse".

Figure 31 shows the five reasons households without toilets cited as being very important or important for getting a toilet (see Annex Table E4 for the complete ranking).

People without toilets clearly indicated their concerns about safety, children's safety and animal attacks during defecation in the open (see Table 24). Answers to these concerns make up 40% of the total. Many people also have shown their concerns and worries during group discussions. In particular, women have shown a stronger sense of worry about the dangers for themselves and children during open defecation.

### 4.5.4 PREFERENCES FOR TOILET OPTIONS

Reasons why households build private toilets focus on safety, privacy, convenience, environmental protection and comfort. During group discussions, many participants counted toilet construction as one of the signs of social status and dignity. Table 25 presents the top five ranked reasons for sanitation coverage of households, segregated results from men and women, and comparing results of the household survey with the FGD.

**FIGURE 31:** HOUSEHOLDS STATING REASONS TO GET A LATRINE FOR THOSE CURRENTLY WITHOUT (1 = NOT IMPORTANT; 5 = VERY IMPORTANT)

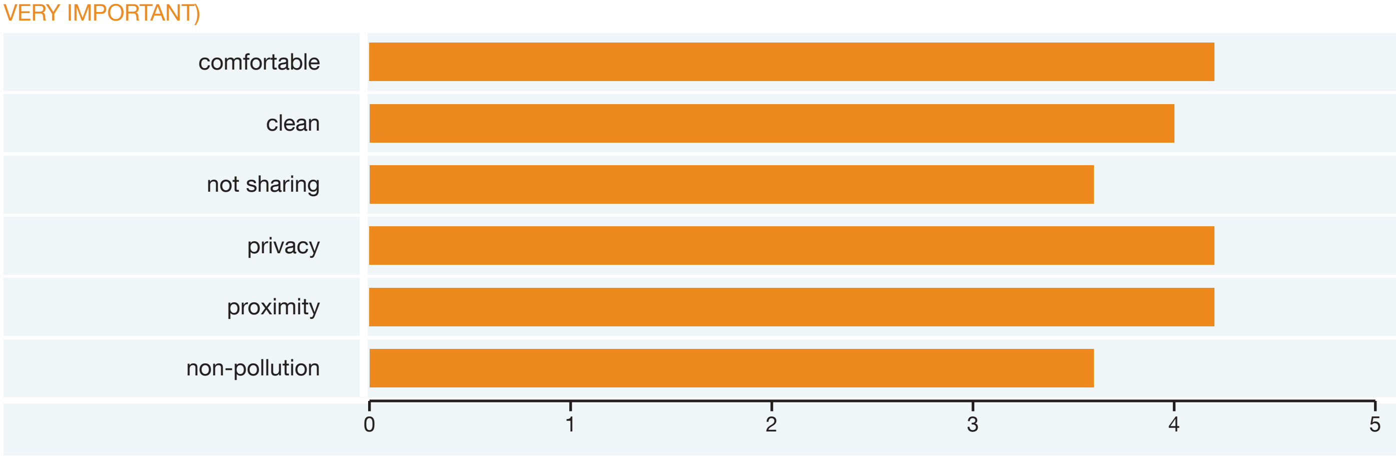



**TABLE 24:** CONCERNS OF PEOPLE WHO PRACTICE OPEN DEFECATION

| Worry | Number of respondents | Answers (%) | | |
|---|---|---|---|---|
| | | never | sometimes | often |
| Do you feel danger during OD? | 56 | 32 | 23 | 1 |
| Have you ever worried about the safety of children? | 53 | 22 | 26 | 5 |
| Have you ever heard about people being attacked by wild animals during OD? | 58 | 34 | 21 | 3 |

**TABLE 25:** REASONS FOR CURRENT SANITATION COVERAGE – TOP FIVE RANKED RESPONSES PER SITE

| | Household interview | Focus Group Discussions | | | |
|---|---|---|---|---|---|
| | | Why families with toilet have a toilet | | Why families without toilet do not have a toilet | |
| | | Men (accounting for heads) | Women (accounting for heads) | Men (accounting for heads) | Women (accounting for heads) |
| **Average rural** | 1. Privacy of toilet 44%<br>2. Proximity to the house 34%<br>3. use toilet on rainy days 17%<br>4. Comfortable location 10%<br>5. avoid snakes and pests 8% | 1. clean19%<br>2. convenient and safe19%<br>3. protect the headwater 18.3%<br>4. alone and not being disturbed 6%<br>5. health 3% | 1. clean 22%<br>2. convenient and safe 15.3%<br>3. protect the headwater 21.7%<br>4. health 13.3%<br>5. save energy 8.3% | 1. high cost 1%<br>2. no space 0.7%<br>3. incapable 0.7%<br>4. never considered this 0.7%<br>5. no one provided facility 3.3% | 1. high cost 5.7%<br>2. no space 2.7%<br>3. incapable 1.3%<br>4. never considered this 3.3%<br>5. no one provided facility 2.6% |
| **Average urban** | 1. Privacy of toilet 27%<br>2. Avoid snakes and pests 26%<br>3. convenient for using on rainy days 23%<br>4. Proximity to house 18%<br>5. comfortable location 11% | 1. convenience, sanitary 8.3%<br>2. environment protection 8.3%<br>3. safety 5.7%<br>4. health 3%<br>5. civilized 2% | 1. safety 10.7%<br>2. convenience, sanitary 10%<br>3. environment protection 7.3%<br>4. health 7.3%<br>5. civilized 3% | 1. limited by location 8%<br>2. limited by money 8%<br>3. limited by city planning 8% | 1. limited by location 12%<br>2. limited by money 12%<br>3. limited by city planning 12% |
| **Average Peri-urban** | 1. privacy of toilet 33%<br>2. avoid snakes and pests 19%<br>3. showering in the toilet 19%<br>4. comfortable location 7%<br>5. proximity to the house 6% | 1. convenience 8.5%<br>2. sanitary 8.5%<br>3. environment protection 8.5%<br>4. safety 8%<br>5. comfort 7% | 1. convenience 10%<br>2. sanitary 10%<br>3. environment protection 10%<br>4. safety 10%<br>5. comfort 6% | 1. no space 10%<br>2. incapable 10%<br>3. use public toilet 10%<br>4. live in rented room 10%<br>5. not necessary 10% | 1. no space 11%<br>2. incapable 11%<br>3. use public toilet 11%<br>4. live in rented room 11%<br>5. not necessary 10% |

Most villagers think an improved private pit latrine is more applicable as it can collect manure and is easy to clean, with the 3-in-1 biogas unit in second place. UDDT is not accepted widely by most households and is ranked in third place because of being of poor quality and requiring a change of habits in using and maintaining it. Rural households without own toilets expect to use public toilets in the community, or improved pit latrines. Urban households with flush toilets have a high level of satisfaction. Among the urban households using public toilets, most of them believe that use of their own toilets is more comfortable and they expect to have a toilet bowl or flush toilet. Peri-urban households using public toilets prefer flush toilets connected to septic tanks or sewerage, and desire to build such a toilet if conditions permit. The following are questions asked during an FGD regarding people's choices and preferences.

**Selection of toilet: If you decide to get a toilet, which toilet do you prefer?** Among the interviewees in rural and peri-urban areas, most of them prefer improved pit latrines, from which they can collect manure. Some desire a 3-in-1 biogas unit. A few prefer UDDT and for some a flush toilet is the least preferred due to lack of a public sewerage system. In urban areas, households can afford apartments that are equipped with private flush toilets connected to a public sewerage system. People renting rooms or living in older buildings without sewerage branches have to use public toilets.

**"What will be the most important feature of your toilet?"** We hope to use a private toilet with privacy. The toilet must be built nearest to the house, odorless and comfortable without flies and insects.

**"What is the major reason for you to get a toilet?"** A private toilet is safe and convenient for household members. We hope that we can use the toilet as needed at any time and have privacy. We can save time when having our own toilet. On the other hand, if other households have built a toilet, we feel embarrassed if we don't have one. An important reason for most households to have private toilets is to save time.

### 4.5.5 DECISION MAKING FOR SANITATION OPTIONS

In rural areas, the choice of sanitation options is largely supplier-driven. Across the rural sites, the households use mostly traditional pit latrines or do not have their own toilets before building new toilets. Building new toilets in rural areas depends on governmental support via different projects (environmental protection projects, poverty alleviation projects, energy-saving projects) and some receive partial support from donors and NGOs. The type of toilet received depends on the option selected by the project or suppliers, so rural people are in a passive situation in most of the external projects. However, some rural households make their own decisions for toilet construction. For example, some households in Xianrendong Village in Puzhehei of Qiubei have built flush toilets and some have improved traditional pit latrines when they engage in farm-based tourism (agritainment).

The decision making for current and future sanitation options in urban areas is decided by the urban sanitation program approach, the so called "strategic urban sanitation." The government, with an urban development plan, has invested and built public sewerage systems and septic tanks. Improvement and construction of sanitary options inside the apartments for urban households are decided on by themselves. For most households, toilets are available in apartments when they move in. Some households can improve the existing sanitation devices to meet their requirements according to their ability to pay.

### 4.5.6 HEALTH IMPACTS

Through FGDs, the study found that urban residents have a lower exposure to risks of water-based diseases due to good hygiene and sanitation options as well as a cleaner external environment.

In contrast, rural populations are exposed to much higher health risks, due to endemic diseases such as schistosomiasis and lithiasis in Dali, as well as adult diseases, such as rheumatism, diarrhea, tummy bugs, colds, high blood pressure, schistosomiasis and lithiasis. From the FGDs, participants estimated that it costs each rural household around US$150 (1,000 yuan) to treat less acute diseases, and a multiple of five to ten times this value for inpatient treatment, with an additional US$75 (500 yuan) income loss from time off productive activities.

The impact of unimproved sanitation and hygiene on children's health is very significant in rural areas. The children in rural areas often have fever, diarrhea, and colds which often occur simultaneously. For a child's severe diarrheal case, it costs US$60 to US$150 (400-1,000 yuan) to use a public health facility and an additional opportunity cost of US$45 to US$90 (300-600 yuan) for parents accompanying children.

The reasons for the disease burden, according to the FGD participants, are poor hygiene and food borne infections. They think that the diseases are indirectly related to water quality: diseases are perceived in some rural communities to be directly related to polluted water.

The case of Puzhangkang village, Luquan county, indicates that villagers suspect that a poorly functioning water supply facility is responsible for diseases including hepatitis, pneumonia, and diarrhea. The reasons for this disease prevalence and incidence are mainly because of a lack of protected piped water. The water source is located far away, which is diverted to the village through open ditches. The water source is often polluted in the course of the delivery, particularly during the rainy season and by garbage that is thrown in the ditches.

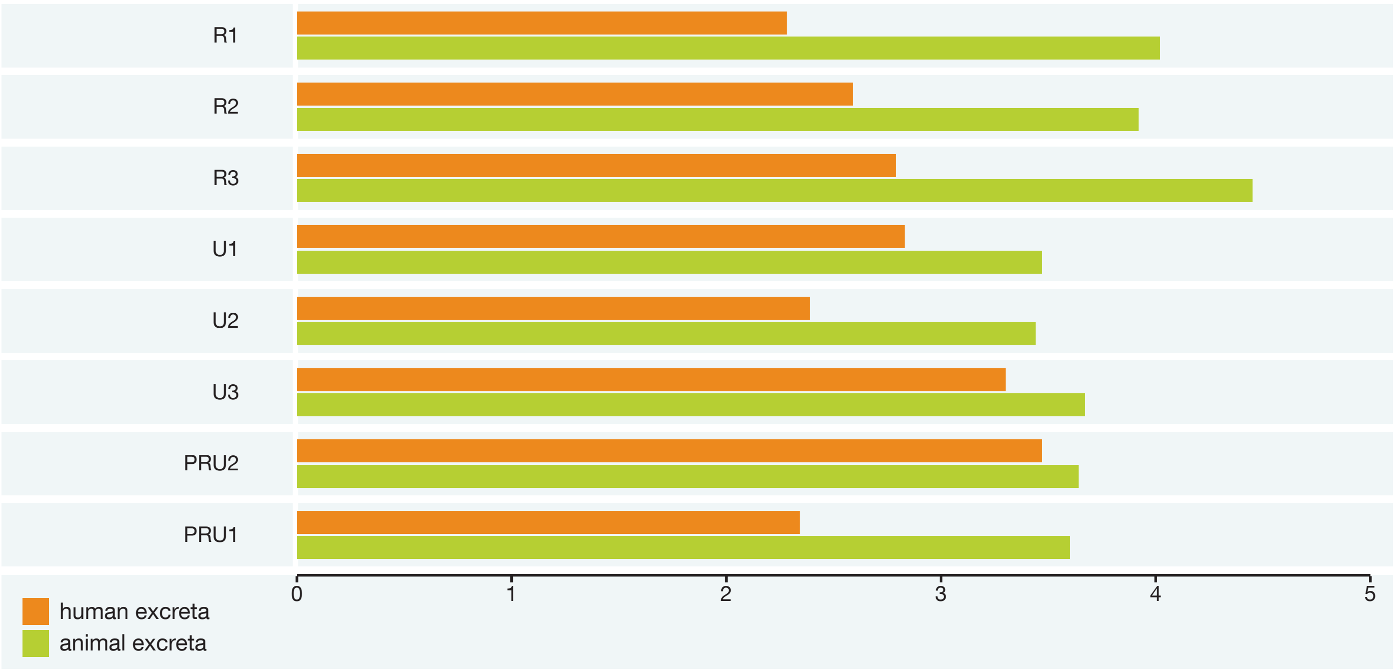
## 4.6 EXTERNAL ENVIRONMENT

The "external" environment refers to the area outside the toilet itself and is not related to toilet-going, and can include living areas, public areas, and private land, which can all be affected by open defecation practices and unimproved toilet options. The consequences of water pollution have already been covered in Section 4.2. The sources of data are mainly the ESI surveys: physical location survey, household interviews, and focus group discussions. Given that the external environment is also spoiled from other sources of poor sanitation – mainly inadequate solid waste management practices – these have also been assessed to understand the contribution of each, and relative preferences regarding their improvement. Households were asked to rate the dirtiness – or level of soiling – of their external environments.

The survey findings indicate that environmental sanitation is worse in rural areas than in urban areas, especially in Kunming-Luquan and Qiubei counties. This occurs for two reasons: first, the procedures for human excreta reuse do not meet sanitary requirements; second, along with the extension of the local stockbreeding, the management of animal excreta remains unsanitary. For example, Luquan County is located in one of the water reservoir areas of Yunnan, and there are several regulations forbidding some activities that might result in water pollution, such as using human and animal excreta as the main source of manure. In Qiubei County, there are many breweries that have developed home-based brewery factories combined with pig breeding by using hops to feed pigs. Along with household economic development, external environmental sanitation is getting worse due to poor management of local sanitation. Table 26 shows scoring of different types of living areas from a household survey.

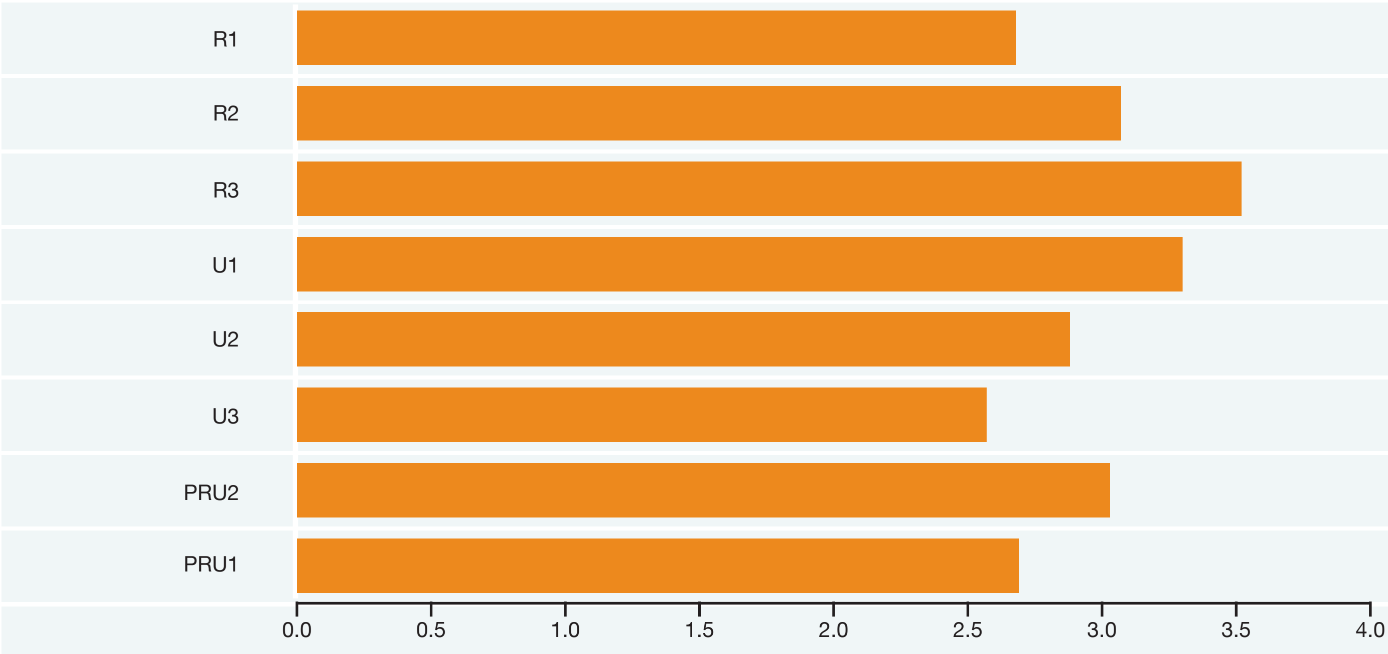
Generally speaking, interviewees all think the animal excreta incurs more pollution than human excreta. Across sites, participant ratings for community areas indicate them to be slightly cleaner than moderate soiling. Animal excreta in private plots causes major soiling, especially in rural areas with an average score of 4.1. The overall community living areas rank as moderately soiled. There is little difference in the scores among urban, peri-urban and rural areas. Figure 32 and Figure 33 show the quality of environmental sanitation in private plots and community living areas, ranked by interviewees in the household survey.

**FIGURE 32:** SCORING OF DIFFERENT TYPES OF LIVING AREAS—PRIVATE PLOTS




(1 = clean, 2 = minor soiling, 3 = moderate soiling, 4 = major soiling, 5 = extreme soiling)

**FIGURE 33:** SCORING OF DIFFERENT TYPES OF LIVING AREAS—COMMUNITY LIVING AREAS




(1 = clean, 2 = minor soiling, 3 = moderate soiling, 4 = major soiling, 5 = extreme soiling)

Figures 34 and 35 show the proportion of households with and without toilets, respectively, with unimproved sanitation practice. The rate of infants of households with no sanitation seen defecating in own or other yards varies across sites from 40% to 90%. Regarding households with toilets, the proportion of open defecation/urination is low, but the proportion seeing children defecating in yards is high.

Figure 36 shows the perceptions of environmental sanitation by option types. The option types including rubbish, sewage, water, smoke, smell, dirt outside, dirt inside, rodents and insects are generally ranked as bad to normal. Sewage is considered as a serious factor in incurring a negative impact on either urban or rural areas, with a score of 2.8 and 3.0 respectively. Rubbish, dirt outside and insects had an average score of 3.0. Smoke is considered to have less environmental impact on both urban and rural areas. Generally, urban areas are perceived to be better than rural and peri-urban areas.

Public opinion on the key areas of the importance of environmental improvement is surveyed in the study. The results indicated that all factors are important with the score being around 4 to 4.4. However, there was little difference among the options. Treatment and management of rubbish, sewage, water, smoke, smell, dirt outside, dirt inside, rodents and insects should all be considered as very important issues in improving environmental sanitation. It is necessary to take comprehensive action instead of doing it piecemeal to achieve the goal of improving environmental sanitation (see annex Table F5).

Poor external environment causes diarrhea

Ginghe village of Dali used to drink ground water from tube wells until three years ago. The poor water quality caused diseases among the villagers. After a governmental project to improve the drinking water supply, the villagers started to use treated piped water. As a result, disease incidence has decreased in the village. However, the external environment in the village is still poor although a public garbage collection tank has been built. Due to poor awareness on public external environmental protection and bad behavior, garbage is put everywhere and animal excrement is seen everywhere in the public environment. This poor external environment in the village has caused the disease incidence to increase.

**FIGURE 34:** PROPORTION OF HOUSEHOLDS WITH UNIMPROVED SANITATION PRACTICE

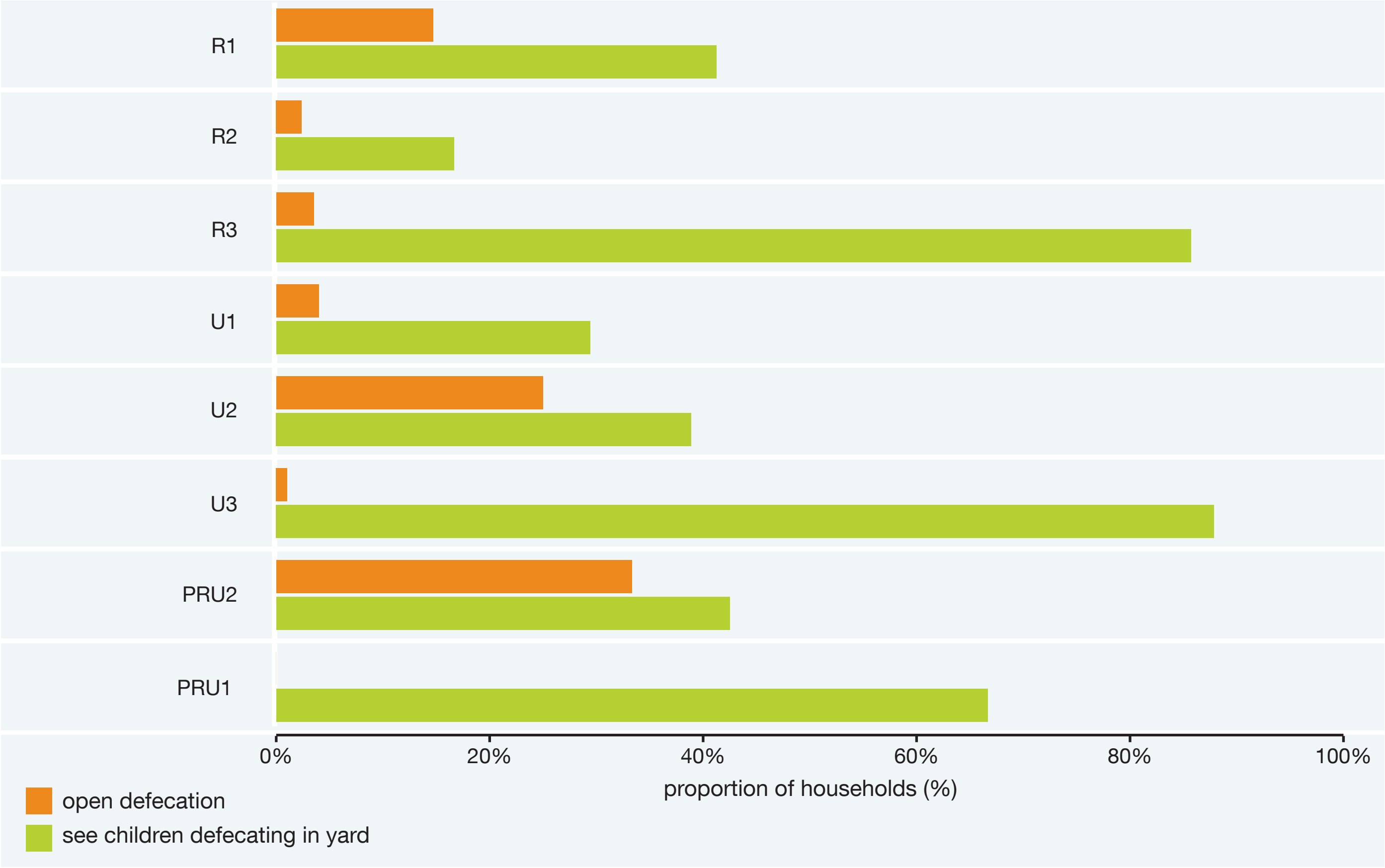



**FIGURE 35:** PROPORTION OF HOUSEHOLDS WITHOUT TOILETS WHO SEE CHILDREN DEFECATING IN EXTERNAL ENVIRONMENT NEAR LIVING QUARTERS (SOMETIMES OR REGULARLY)

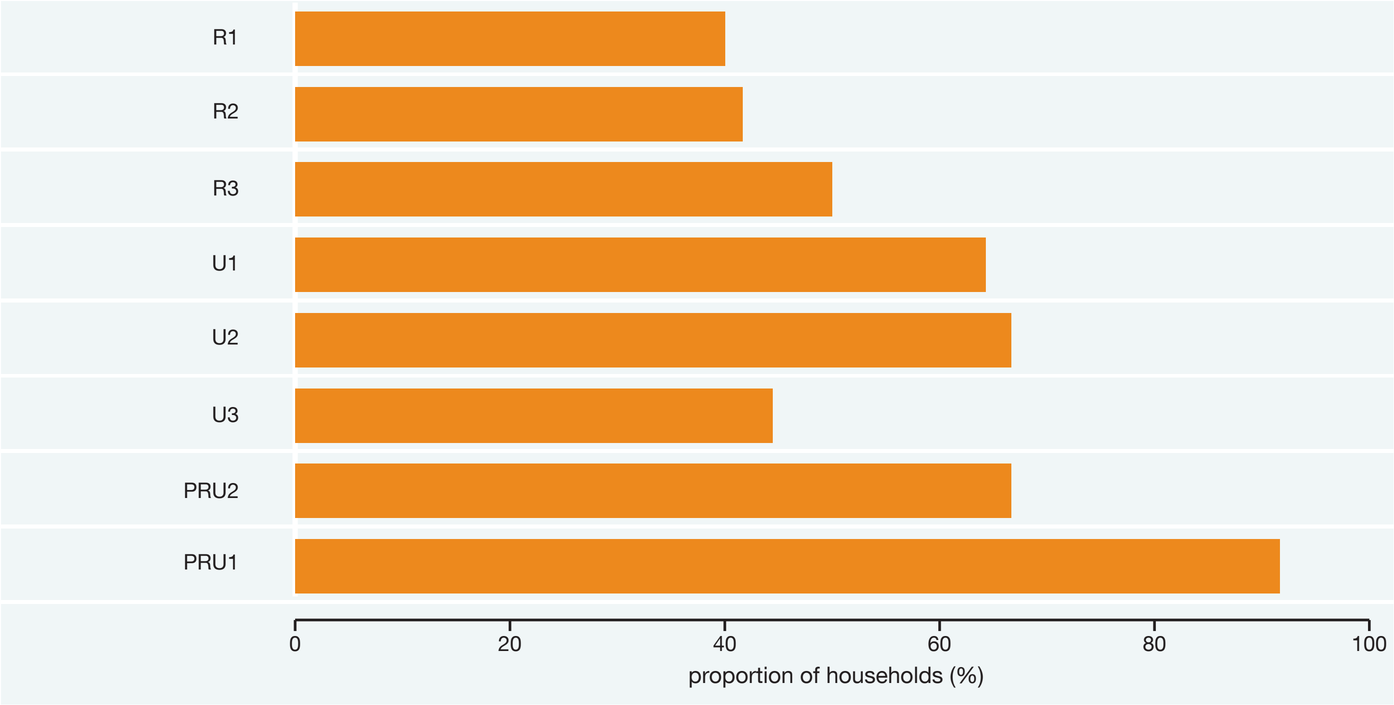
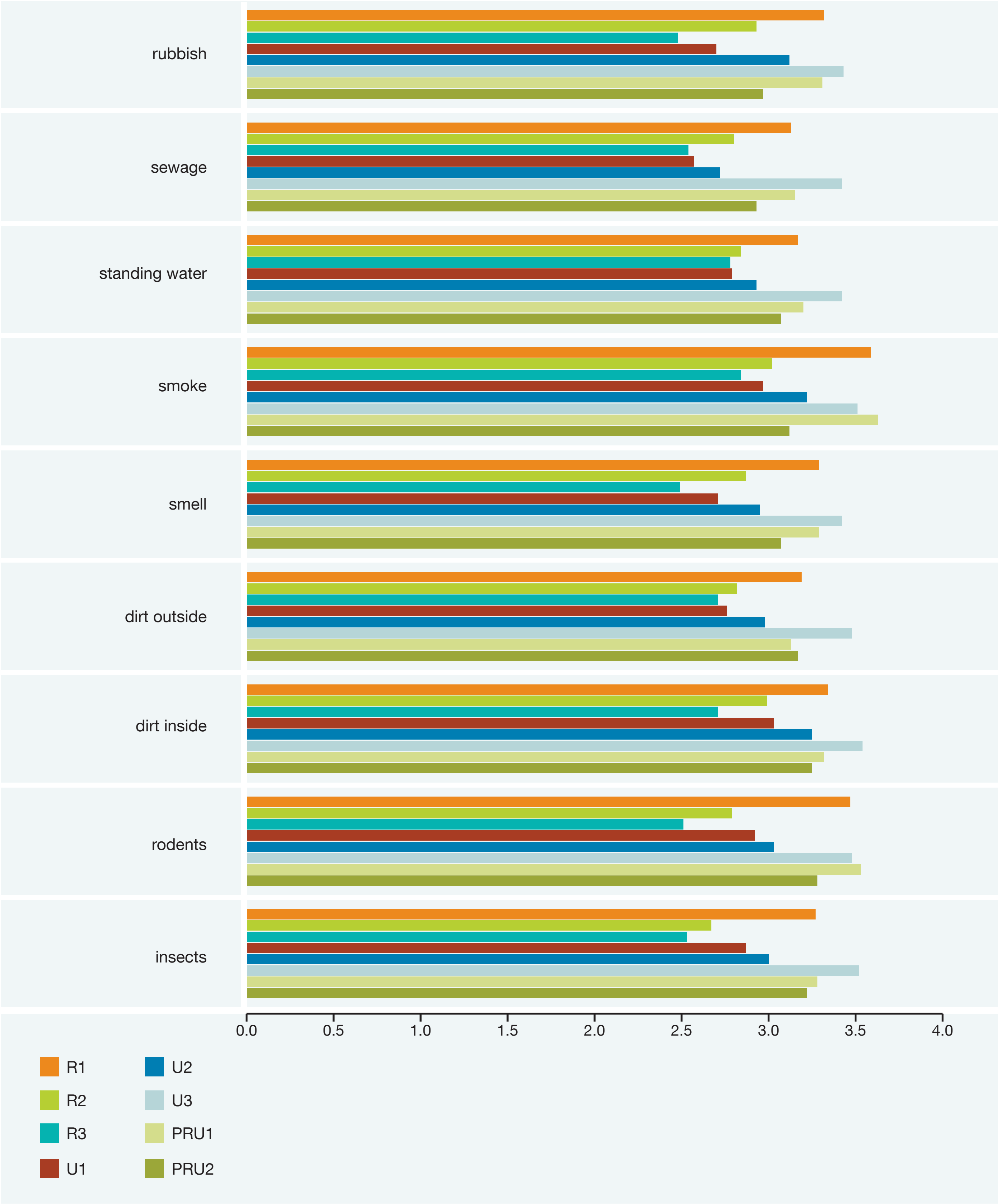


**FIGURE 36:** PERCEPTIONS OF ENVIRONMENTAL SANITATION STATE, BY OPTION TYPE (1= VERY BAD; 5 = VERY GOOD)



A case in Shangguan Town of Dali Prefecture

The children in the town often suffer from bacterial diarrhea and colds, and the adults rank the disease incidence including gynecological diseases, appendicitis, diarrhea, gastroenteritis disease, and lithiasis. They think that these diseases are related to the poor external environment and unsanitary living habits. Domestic waste, agricultural waste, dust and other problems co-exist in the town, which are the sources for air and water pollution. For example, poor water quality in the rainy season is caused by discharged waste in streams and rivers; in the dry season, lack of sufficient water sources make water quality poor. Sanitation behavior in private and public locations is also the main factor in causing disease incidence. Unsafe food conditions with unsanitary processing and use of unsafe material for processed food also cause diarrhea and other diseases.

The perception of local people on the external environment

The residents of Liangyuan Community in Kunming city think that the external environment around their community is very bad with domestic waste and industrial solid waste from a car repair factory. Animal excrement is seen in the neighborhood, smelly water canals, flies, mosquitoes, paint smells, noise pollution all disgust the residents. This poor external environment affects the residents quality of life.

The ESI survey in Dali Old Town suggests that women are much more sensitive to a poor environment, citing the presence of human and animal excrement, domestic garbage and urine in the back streets of the town. Female respondents think that the bad external environment affects the health of the residents as well as the reputation of Dali Old Town as a famous tourist site. Male respondents think the environment is reasonably clean. However, both men and women say they are willing to pay for better public waste management.

Scores provided by villagers from rural areas on the environment rank worse than those of urban residents. The external environments of most villages are very bad, due to lack of management of domestic waste and animal excrement, causing river and water resource pollution. In addition, flies, mosquitos and rats are common in rural communities, which all contribute towards disease. Although it is necessary to improve the quality of the external environment, some villagers are not willing to pay for better waste management due to their poor financial situation.

## 4.7 SUMMARY OF LOCAL BENEFITS

Table 26 shows the summary breakdown of benefits. In rural areas, households could save an average of US$331 annually for health, water and access time benefits of improved basic sanitation, with an additional US$47 from UDDT or US$77 for biogas. In urban areas, the savings are US$344, compared with US$303 in peri-urban areas.

**TABLE 26:** SCORING OF DIFFERENT TYPES OF LIVING AREAS FROM A HOUSEHOLD SURVEY

| Site | Private plots | | Community living areas (market, roadside) |
|---|---|---|---|
| | Human excreta | Animal excreta | Human excreta, animal excreta & solid waste |
| R1 (Rural-Luquan: Kunming) | 2.28 | 4.02 | 2.68 |
| R2 (Rural: Dali) | 2.59 | 3.92 | 3.07 |
| R3 (Rural: Qiubei) | 2.79 | 4.45 | 3.52 |
| U1 (Urban: Kunming) | 2.83 | 3.47 | 3.30 |
| U2 (Urban: Dali) | 2.39 | 3.44 | 2.88 |
| U3 (Urban: Qiubei) | 3.30 | 3.67 | 2.57 |
| PRU1 (Peri-urban-Jinning: Kunming) | 2.34 | 3.60 | 2.69 |
| PRU2 (Peri - urban-Zhoucheng: Dali) | 3.47 | 3.64 | 3.03 |
| **Average Rural** | **2.53** | **4.13** | **3.09** |
| **Average Urban** | **2.84** | **3.52** | **2.91** |
| **Average Peri-urban** | **2.9** | **3.6** | **2.86** |
| **Average (All)** | **2.76** | **3.75** | **2.95** |

(1 = clean, 2 = minor soiling, 3 = moderate soiling, 4 = major soiling, 5 = extreme soiling)

The most important contributor to the quantified benefits is related to health improvements of improved sanitation. Benefits of improved sanitation and hygiene can avoid health costs by reducing disease cases, mortality, and DALYs, averting an annual health care cost per household of US$280 in rural, US$277 in urban, and US$196 in peri-urban areas. Improved sanitation can improve water quality, and thus can save water access costs and treatment costs ranging from US$8.5 to US$9.3 per household annually in urban and rural areas, respectively. Improved sanitation can save productivity costs of US$44, US$60 and US$88 per household annually in rural, urban and peri-urban areas, respectively. Other intangible benefits are also perceived by the users. These benefits are summarized in Table 27.

**TABLE 27:** SUMMARY OF LOCAL IMPACTS OF SANITATION IMPROVEMENT (2009)

| Benefit | Benefits of improved sanitation and hygiene | | | |
|---|---|---|---|---|
| | Quantitative benefit (US$/household, annual) | | | Qualitative or Other Benefit |
| | Rural | Urban | Peri-urban | |
| HEALTH | | | | |
| Health burden/quality of life<br>• Cases/person<br>• Mortality/1000 population<br>• DALYs/1000 population | <br>1.93<br>0.92<br>16.0 | <br>1.43<br>0.67<br>13.0 | <br>1.47<br>0.69<br>12.0 | • Avoided pain and discomfort from illness (captured partially in the DALY losses)<br>• Avoided costs from other diseases associated with poor sanitation |
| **Health costs averted** | **280** | **277** | **196** | *Refer to Tables 7 to 12 and Figures 10 to 13.* |
| Health care | | | | |
| OD to Basic | 34 | - | 27 | |
| OD to Sewerage | - | 36 | - | |
| Productivity costs averted | | | | |
| OD to Basic | 38 | - | 25 | |
| OD to Sewerage | - | 34 | - | |
| Mortality costs averted | | | | |
| OD to Basic | 207 | - | 144 | |
| OD to Sewerage | - | 206 | - | |
| WATER | | | | |
| Access cost savings | 2 | 2 | 2 | Improved water quality (smell, appearance, less contaminants) for drinking, domestic purposes, recreation and other.<br>*Refer to Figure 16* |
| Treatment cost savings | 7 | 7 | 7 | |
| **Access time** | **44** | **60** | **88** | • Avoided discomfort from having to queue<br>• Households without toilets mostly consider "comfort" and "proximity" the most important reasons to get a toilet<br>• Time loss associated with urination is excluded<br>*Refer to Table 18, Table 19 and Figure 28* |
| **Intangibles** | - | - | - | • Comfort associated with use of clean toilets<br>• Pride in having a toilet, especially if expensive<br>• Privacy and not being seen going to the toilet<br>• Safety of women and children<br>• Confidence to invite guests to the house<br>*Refer to Figure 31 and Table 25* |
| **External environment** | - | - | - | • Cleaner surrounding areas<br>• Less exposure to insects and rodents<br>*Refer to Annex Table F5* |
| **Reuse: composting** | 47 | - | - | • Cleaner surroundings and averted water pollution |
| **Reuse: biogas unit** | 77 | - | - | |

"-" not calculated

# V. Costs of Improved Sanitation and Hygiene

This chapter presents the costs of improved sanitation from different perspectives – investment versus recurrent, economic versus financial, and by financing source (payer). At the end, marginal costs of moving up the sanitation ladder are presented.

## 5.1 COST SUMMARIES

Table 29 to Table 30 show the aggregated costs for each sanitation option across rural, urban and peri-urban field sites. The results show that the investment, recurrent and average annual costs of sanitation options are directly related to the level of sanitation improvement.

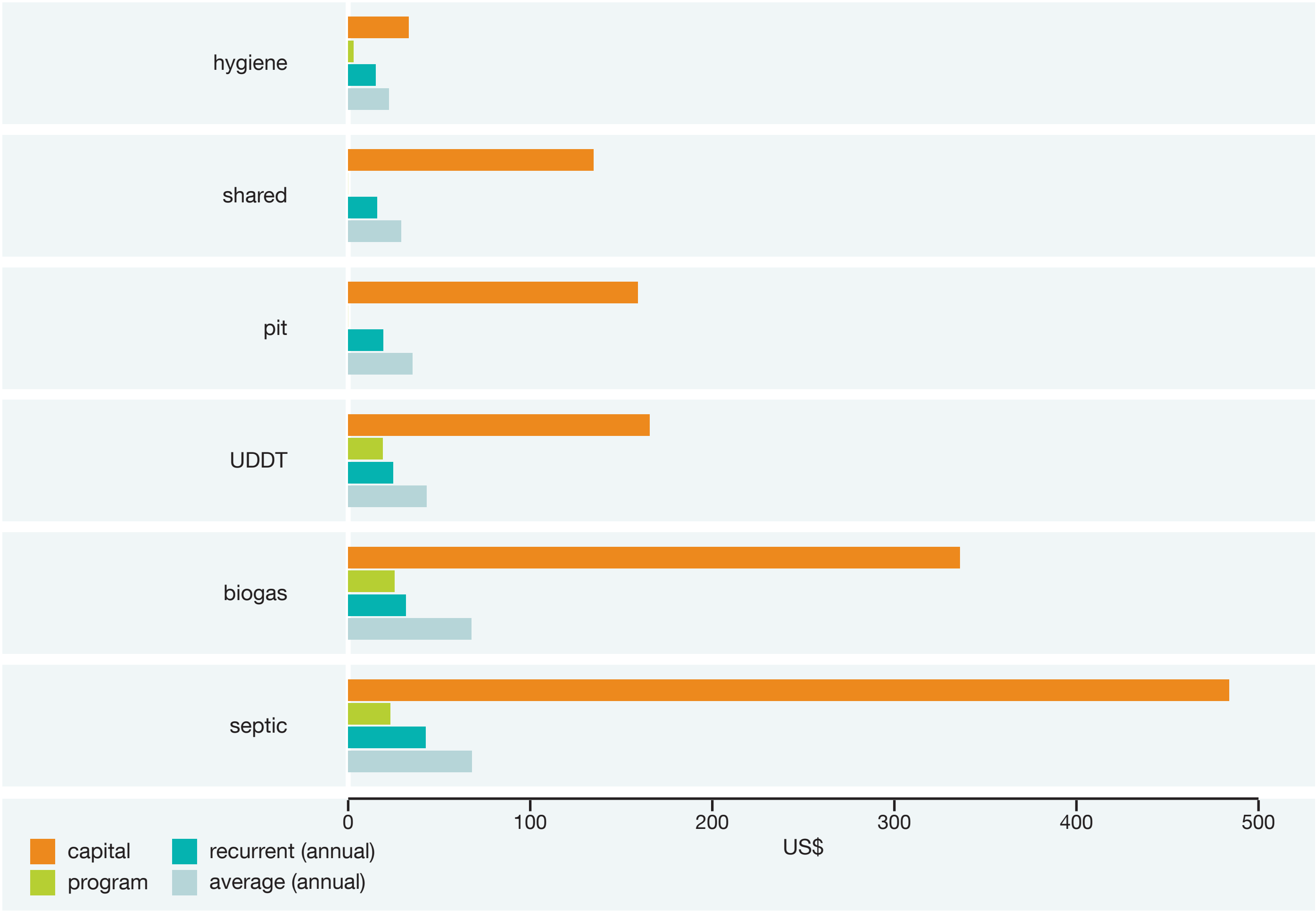
### 5.1.1 RURAL AREAS

In rural areas, the average investment cost per household for shared, pit latrines and UDDTs ranges from US$135 to US$185. More than twice this cost is the 3-in-1 biogas unit, which costs US$361. Rural households invest an average US$507.4 for a septic tank. Average annual recurrent cost per households for hygiene is US$15.1 and for the different sanitation options ranges from US$15.8 to US$42.6. Total annual costs per household, including both investment and recurrent, averages between US$29 and US$68.

**TABLE 28:** AVERAGE RURAL COST PER HOUSEHOLD FOR DIFFERENT SANITATION AND HYGIENE OPTIONS, USING FULL (ECONOMIC) COST (US$, YEAR 2009)

| Cost Item | Hygiene | Shared | Pit | UDDT | Biogas | Septic |
|---|---|---|---|---|---|---|
| INVESTMENT COSTS: INITIAL ONE-OFF SPENDING | | | | | | |
| 1. Capital | 33.4 | 134.7 | 159.1 | 165.7 | 336.0 | 484.0 |
| 2. Program | 2.9 | 0.0 | 0.0 | 19.0 | 25.5 | 23.3 |
| **Sub-total** | 36.3 | 134.7 | 159.1 | 184.7 | 361.4 | 507.4 |
| RECURRENT COSTS: AVERAGE ANNUAL SPENDING | | | | | | |
| 3. Operation | 5.4 | 4.4 | 5.3 | 5.7 | 10.4 | 15.4 |
| 4. Maintenance | 6.6 | 11.4 | 14.1 | 14.6 | 16.8 | 21.2 |
| 5. Program | 2.9 | 0.0 | 0.0 | 4.4 | 4.4 | 6.0 |
| **Sub-total** | 15.1 | 15.8 | 19.3 | 24.7 | 31.6 | 42.6 |
| AVERAGE ANNUAL COST CALCULATIONS | | | | | | |
| Duration | 5.0 | 10.0 | 10.0 | 10.0 | 10.0 | 20.0 |
| Cost/household | 22.3 | 29.2 | 35.3 | 43.2 | 67.8 | 68.0 |
| Cost/capita | 6.4 | 8.3 | 10.1 | 12.3 | 19.4 | 19.4 |
| OF WHICH: | | | | | | |
| % capital | 0.3 | 0.5 | 0.5 | 0.4 | 0.5 | 0.4 |
| % program | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % recurrent | 0.7 | 0.5 | 0.5 | 0.6 | 0.5 | 0.6 |
| *Observations* | 403 | 14 | 118 | 14 | 43 | 214 |

**FIGURE 37:** ECONOMIC COSTS PER RURAL HOUSEHOLD FOR MAJOR ITEMS (US$, YEAR 2009)




Program costs reflecting software items such as promotion, education and monitoring contribute a very small proportion of total costs for all the sanitation options, accounting for a maximum of 4.4% of total costs for UDDT in rural areas. Specifically, there was no measured program cost from the governments or any other financiers on shared or pit latrines across the field sites, although officially the provincial government should allocate funds for the programs to implement interventions. There is a limited program cost on UDDT in Qiubei from the Swiss Re-insurance Company and the German Embassy in Beijing. Program costs for all the sanitation options across the field sites account for less than 4.4% of the total cost on an average basis. Limited funds were invested in promotion, education and monitoring of sanitation options in Yunnan Province.

Recurrent costs in rural areas are 67% of the overall annualized cost for hygiene and 47% for biogas units. Shared toilet, pit latrine and UDDT have an average annual recurrent cost ranging from US$15.8 to US$24.7. The 3-in-1 biogas unit has an average annual recurrent cost of US$31.6. The most advanced sanitation options including septic tank have the highest recurrent cost ranging from US$46 to US$74.2 annually due to more spending on water supply and maintenance.

Across all the rural sites, the cumulative recurrent costs for a 20-year duration for all the sanitation options are higher than the initial investment cost, accounting for more than 50% of total cost, except for the 3-in-1 biogas unit which accounts for 47% of total cost.

In rural areas, hygiene costs start with an initial one-off spending of US$36.3 and follow with an annual recurrent hygiene cost of US$15.1.

### 5.1.2 URBAN AREAS

Table 29 summarizes the average cost per urban household for different sanitation and hygiene options. The average investment cost per household for hygiene is US$40.8. The cost for shared and public toilets, pit latrines and UDDT ranges from US$137.6 to US$188.8. Septic tanks (with septage management) and sewerage range from US$522.2 to US$684.8. Average annual recurrent cost per household ranges from US$16.1 for shared toilets to US$74.2 for sewerage. Average annual cost per household calculated for the whole life period ranges from US$26.6 for hygiene to US$108.5 for sewerage.

Capital investment accounts for 24% to 45% of the total cost,up to 4.3% on program costs. The percentage of recurrent cost in total cost ranges from 54% to 74%.

Septage with management refers to centralized sanitization treatment for wastes from septic tanks, and the cost includes the toilet itself and the investment and recurrent cost of the centralized treatment facilities. Sewerage refers to the flush toilets connected to a sewerage system, and its cost includes household investment on the toilet, sewerage and discharge of household wastewater. The actual utilization is lower than the optimal capacity, which is considered in the cost calculation.

### 5.1.3 PERI-URBAN AREAS

Table 30 summarizes the average cost per peri-urban household for different sanitation and hygiene options. Average investment cost per household for hygiene US$40.5, US$145 for shared, pit and UDDT; the average household investment for a septic tank is US$522.9. The average recurrent cost per household ranges from US$18.2 for hygiene to US$45.4 for a septic tank. Average annual cost calculated for the whole life period of sanitation options ranges from US$26.3 for hygiene to US$71.5 for a septic tank. Capital (hardware) of the different sanitation options range from 29 to 45%, and recurrent (O&M) is 69% of the total cost.

**TABLE 29:** SUMMARY OF AVERAGE COST PER URBAN HOUSEHOLD FOR DIFFERENT SANITATION AND HYGIENE OPTIONS, USING FULL (ECONOMIC) COST (US$, YEAR 2009)

| Cost Item | Hygiene | Shared | Public toilet | Pit | UDDT | Septic | Septage optimal | Septage actual | Sewage optimal | Sewerage actual |
|---|---|---|---|---|---|---|---|---|---|---|
| INVESTMENT COSTS: INITIAL ONE-OFF SPENDING | | | | | | | | | | |
| 1. Capital | 37.9 | 133.2 | 187.4 | 164.0 | 168.3 | 497.9 | 537.2 | 571.7 | 629.9 | 653.3 |
| 2. Program | 2.9 | 4.4 | 13.9 | 0.0 | 20.5 | 24.2 | 27.8 | 30.7 | 29.4 | 31.3 |
| **Sub-total** | 40.8 | 137.6 | 201.3 | 164.0 | 188.8 | 522.2 | 565.1 | 602.4 | 659.3 | 684.8 |
| RECURRENT COSTS: AVERAGE ANNUAL SPENDING | | | | | | | | | | |
| 3. Operation | 6.6 | 5.9 | 14.6 | 5.9 | 7.3 | 18.4 | 24.2 | 24.6 | 27.8 | 28.4 |
| 4. Maintenance | 9.1 | 8.1 | 8.8 | 13.8 | 17.6 | 23.3 | 31.5 | 32.2 | 40.1 | 41.1 |
| 5. Program | 2.9 | 2.2 | 5.1 | 0.0 | 4.4 | 4.4 | 4.4 | 4.8 | 4.4 | 4.7 |
| **Sub-total** | 18.4 | 16.1 | 28.5 | 19.6 | 29.3 | 46.0 | 60.0 | 61.6 | 72.3 | 74.2 |
| AVERAGE ANNUAL COST CALCULATIONS | | | | | | | | | | |
| Duration | 5.0 | 10.0 | 10.0 | 10.0 | 10.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| Cost/household | 26.6 | 29.9 | 48.7 | 35.9 | 48.2 | 72.1 | 88.3 | 91.7 | 105.2 | 108.5 |
| Cost/capita | 7.6 | 8.5 | 13.9 | 10.3 | 13.8 | 20.6 | 25.2 | 26.2 | 30.1 | 31.0 |
| OF WHICH: | | | | | | | | | | |
| % capital | 0.3 | 0.4 | 0.4 | 0.5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| % program | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % recurrent | 0.7 | 0.5 | 0.6 | 0.5 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 |
| *Observations* | 257 | 2 | 16 | 26 | 3 | 156 | 10 | 10 | 44 | 44 |

**FIGURE 38:** ECONOMIC COSTS PER URBAN HOUSEHOLD FOR MAJOR ITEMS (US$, YEAR 2009)

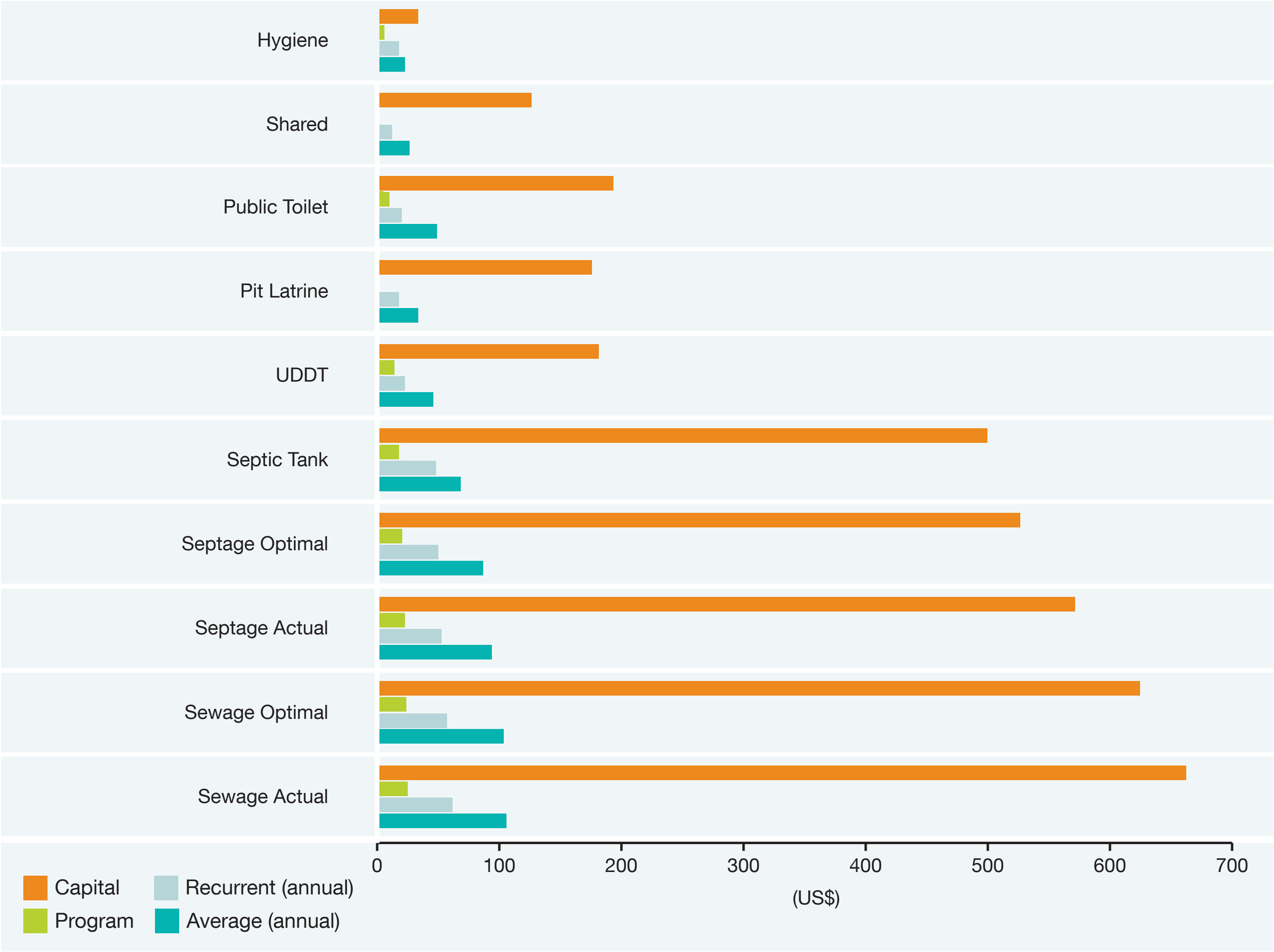



**FIGURE 39:** ECONOMIC COSTS PER PERI-URBAN HOUSEHOLD FOR MAJOR ITEMS (US$, YEAR 2009)

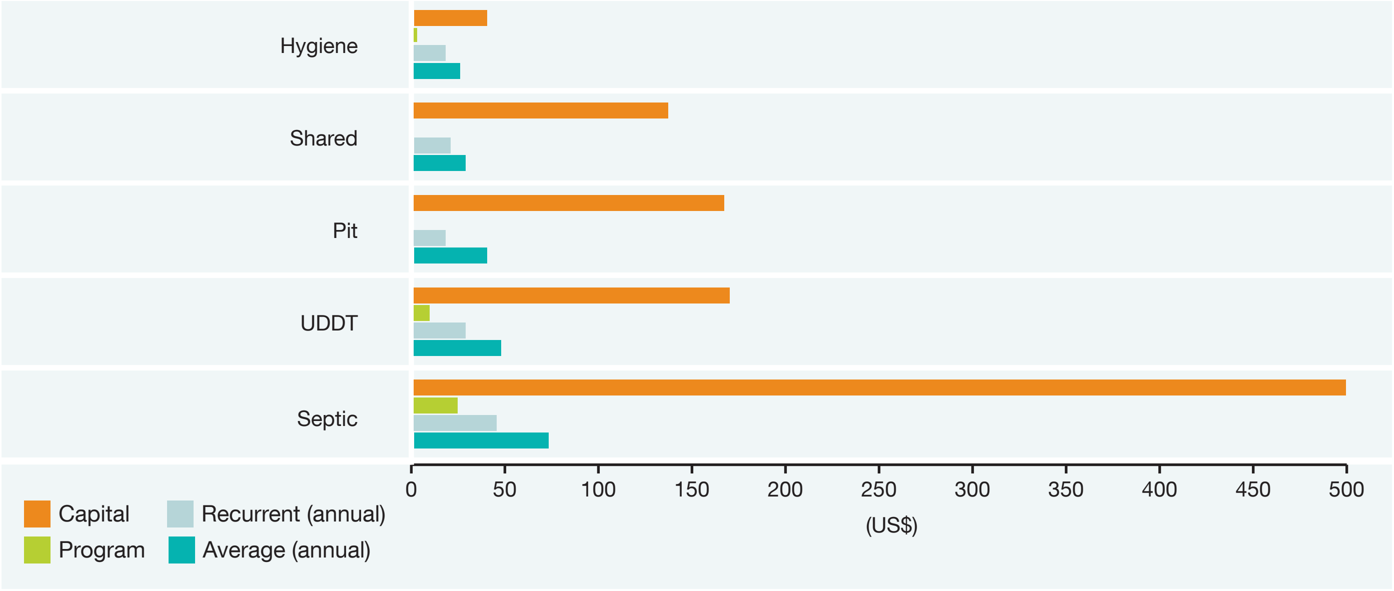


**TABLE 30:** SUMMARY OF AVERAGE COST OF A PERI-URBAN HOUSEHOLD FOR DIFFERENT SANITATION AND HYGIENE OPTIONS, USING FULL (ECONOMIC) COST (US$, YEAR 2009)

| Cost Item | Hygiene | Shared | Pit | UDDT | Septic |
|---|---|---|---|---|---|
| INVESTMENT COSTS: INITIAL ONE-OFF SPENDING | | | | | |
| 1. Capital | 37.6 | 135.3 | 166.7 | 169.2 | 498.3 |
| 2. Program | 2.9 | 0.0 | 0.0 | 17.0 | 24.6 |
| **Sub-total** | 40.5 | 135.3 | 166.7 | 186.4 | 522.9 |
| RECURRENT COSTS: AVERAGE ANNUAL SPENDING | | | | | |
| 3. Operation | 6.9 | 5.9 | 5.9 | 7.9 | 18.3 |
| 4. Maintenance | 8.3 | 11.4 | 14.8 | 15.8 | 22.7 |
| 5. Program | 2.9 | 0.0 | 0.0 | 4.4 | 4.4 |
| **Sub-total** | 18.2 | 17.3 | 20.6 | 28.3 | 45.4 |
| AVERAGE ANNUAL COST CALCULATIONS | | | | | |
| Duration | 5.0 | 10.0 | 10.0 | 10.0 | 20.0 |
| Cost/household | 26.3 | 30.8 | 37.3 | 46.8 | 71.5 |
| Cost/capita | 7.5 | 8.8 | 10.7 | 13.4 | 20.4 |
| OF WHICH: | | | | | |
| % capital | 0.3 | 0.4 | 0.4 | 0.4 | 0.3 |
| % program | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % recurrent | 69.1 | 56.0 | 55.4 | 60.2 | 63.5 |
| *Observations* | 199 | 71 | 29 | 24 | 75 |

In comparing different settlements, rural households adopt similar sanitation options as peri-urban households. There is little difference between rural and peri-urban households in investment cost, recurrent and average annual cost. The cost for sewerage for urban households has a higher investment cost, annual recurrent cost as well as the average annual cost. For the same sanitation option, the overall cost in urban areas is higher than that in peri-urban and in rural areas since the urban population tends to invest more in hygiene than the rural population due to higher incomes and consumption level.

## 5.2 ECONOMIC VERSUS FINANCIAL COST

Figure 40 depicts the proportion of financial cost to overall economic cost including capital, program, annual recurrent, and average annual across all the sanitation options. The data sources for each sanitation option are based on an aggregation of the field site implementing each sanitation option. The proportion of financial cost for capital investment for all the sanitation options ranges from 58% for hygiene to 86% for septic tanks. Although the overall economic cost for program investment is small, financial costs as a proportion of total program cost ranges from 50 to 88%. Financial costs contribute from 44 to 65% of the total recurrent cost. For overall annual equivalent cost, financial cost contributes from 54 to 68%. Annex Table G4 provides more details.

## 5.3 SOURCES OF FINANCING FOR SANITATION AND HYGIENE

Figures 41 to 43 show the sources of financing in rural, urban and peri-urban sites, respectively. According to the investigation in Dali, Kunming and Qiubei, sanitation and hygiene interventions are largely financed by individual households with contributions also made by different government agencies and NGOs. In rural areas, 3-in-1 biogas units are mostly financed by the forestry bureau and poverty alleviation office, and improved pit latrines and septic tanks are co-financed by the Yunnan Environmental Protection Department (YEPD).

**FIGURE 40:** PROPORTION OF TOTAL (ECONOMIC) COSTS WHICH ARE FINANCIAL, ACROSS ALL FIELD SITES

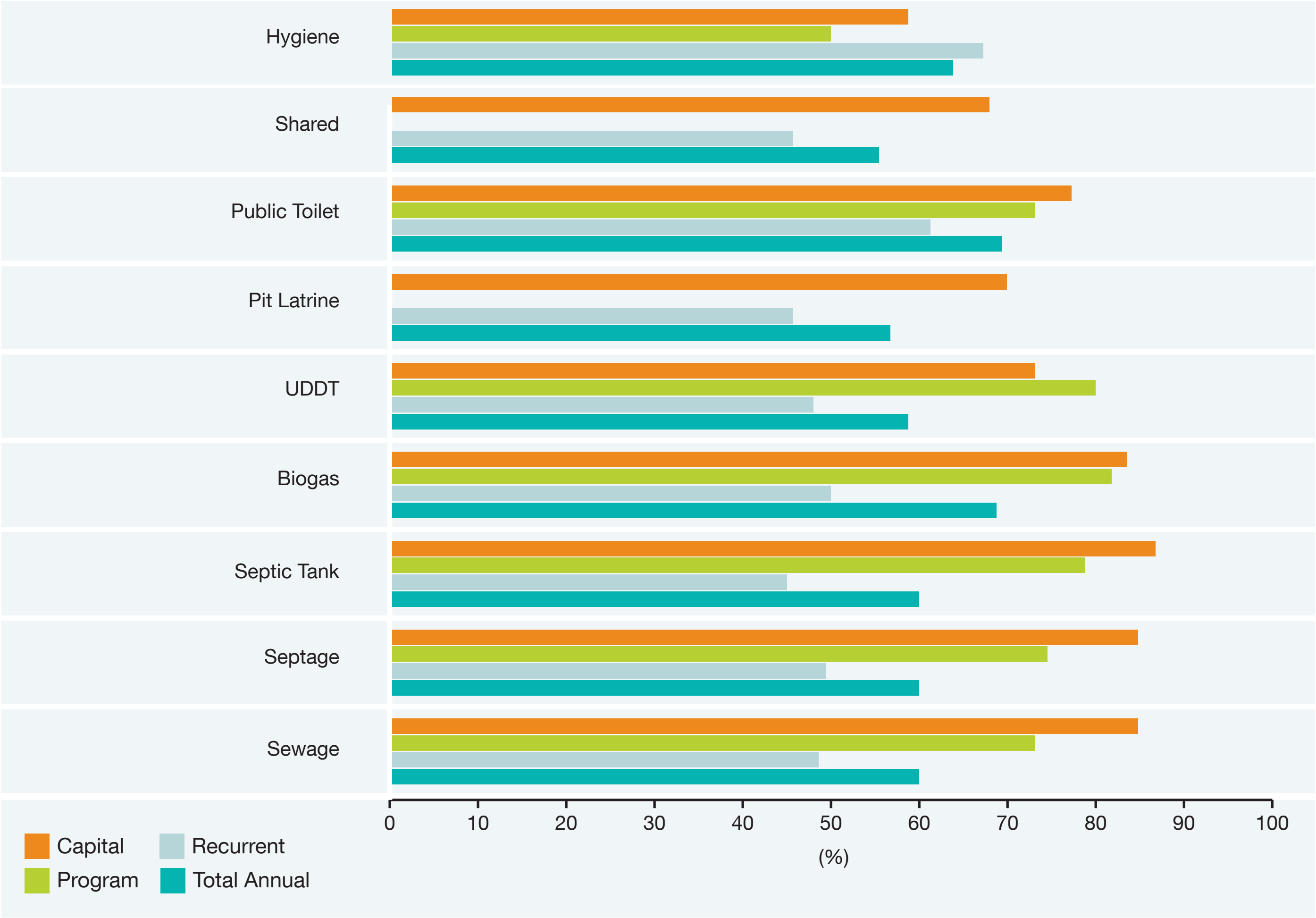
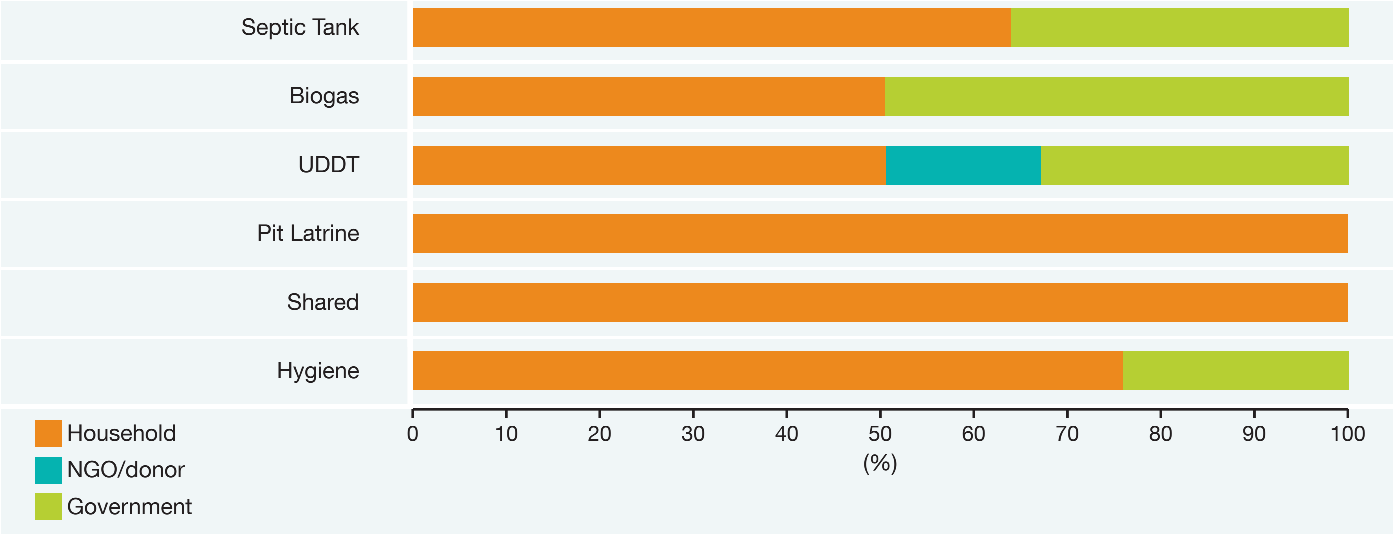



**FIGURE 41:** PROPORTION OF RURAL SANITATION COSTS FINANCED FROM DIFFERENT SOURCES (%)



Shared and pit latrines are commonly built by the users autonomously without financing from government or other institutes. Septic tanks, biogas units and UDDT in rural areas are financed by government agencies. Local and international NGOs also finance sanitation in rural areas, but at smaller scale in comparison with government agencies. Government funds tend to finance initial capital outlay on sanitation and hygiene, so when recurrent costs are considered, government financing accounts for roughly 30% of overall sanitation costs. For example, government financing of overall cost varies from 22% for septic tanks to 34% for biogas units. In some areas, UDDT is financed by international NGOs accounting for 21% of overall cost. In addition, household financing is partially through non-financial contributions such as own labor for construction and maintenance, and locally collected materials.

In urban or peri-urban areas, the Construction Bureau finances the sewerage trunk construction as part of the public infrastructure of the city. Urban households pay for the flush-toilets, washrooms, septic tanks, sewerage branches and maintenance, which are included in the cost of the apartment. Public toilets in urban or peri-urban areas are mostly financed by the local governments including initial capital and maintenance, while users pay the operational costs. Household flush toilets connected to septic tanks have household financing of 70% and governmental investment of 30%. The governmental investment funds are used for construction of sewerage and wastewater treatment plants. Fifty-eight percent of septage treatment facility costs are financed by households and 42% by the government. Fifty-one percent of sewerage costs are financed by households and 49% financed by the government.

**FIGURE 42:** PROPORTION OF URBAN SANITATION COSTS FINANCED FROM DIFFERENT SOURCES (%)

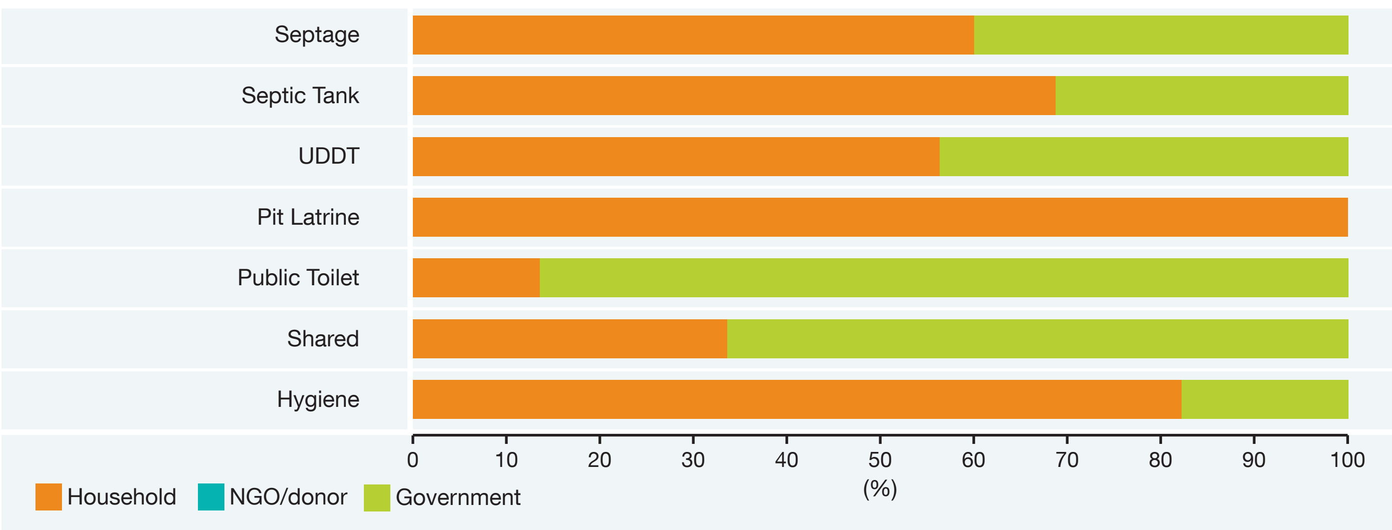
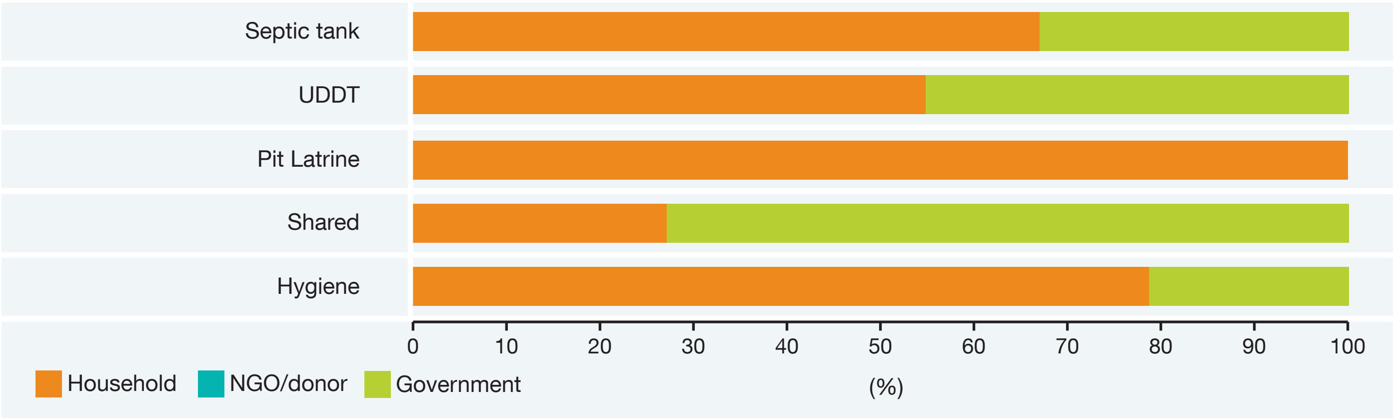



**FIGURE 43:** PROPORTION OF PERI-URBAN SANITATION COSTS FINANCED FROM DIFFERENT SOURCES (%)



In peri-urban areas, shared toilets are co-financed 70% by the government including initial capital and maintenance, and users pay the operational cost. Pit latrines are financed totally by households. Fifty-six percent of UDDTs are financed by households and 44% by the government. Seventy percent of septic tanks are financed by households and 30% by the government. Hygiene interventions receive approximately 80% financing from the households and 20% from the government across all the field sites.

## 5.4 COSTS OF MOVING UP THE LADDER

This section describes the costs of moving up the sanitation ladder. The ladder is arranged not by superiority of the option performance, but in terms of its cost. These data reflect the weighted average of the field sites – i.e. those field sites with more observations have greater weight in the average result. Septic tanks and sewerage at the top of the sanitation option cost ladder have a total economic cost per household of US$1400.5 and US$ 2169.9 respectively. Second, 3-in-1 biogas units have a total economic cost per household of US$677.6. Rural shared pit latrines and private pit latrines have a total economic cost of US$ 310.2 and US$357.0. The economic cost of UDDT per household is US$456.7, and hygiene is US$129.6. Moving up the ladder involves a cost saving when hardware is reused.

Table 31 shows that households moving from rural shared pit latrines, private pit latrines, UDDT, and biogas units to sewerage respectively, have the full cost of the targeted sanitation option of sewerage of US$2170, and from septic tank to sewerage, households will pay an incremental cost of US$769.

Moving up the ladder from pit latrines to biogas units involves a partial cost saving due to the reused hardware. Also, moving up from septic tanks to sewerage involves a partial cost saving. All the other sanitation options moving up to the targeted options need full cost because of the need to invest in the full hardware costs.

**TABLE 31:** MARGINAL COSTS OF CLIMBING THE SANITATION LADDER (AVERAGE ALL SITES) (US$, YEAR 2009)

| | | Hygiene | Shared toilet | Pit latrine | UDDT | Biogas | Septic tank | Public toilet with sewerage | Sewerage actual |
|---|---|---|---|---|---|---|---|---|---|
| Duration | | 5.0 | 10.0 | 10.0 | 10.0 | 10.0 | 20.0 | 20.0 | 20.0 |
| Sub-total investment | | 40.8 | 136.3 | 161.2 | 185.9 | 361.4 | 515.1 | 201.3 | 684.8 |
| Sub-total annual recurrent | | 17.7 | 17.4 | 19.6 | 27.1 | 31.6 | 44.2 | 28.5 | 74.2 |
| Total economic costs | | 129.6 | 310.2 | 357.0 | 456.7 | 677.6 | 1,400.5 | 772.2 | 2,169.9 |
| | | | Shared | Pit latrine | UDDT | Biogas | Septic tank | Public toilet with sewerage | Sewerage actual |
| | Shared | | - | 357.0 | 456.7 | 677.6 | 1,400.5 | 772.2 | 2,169.9 |
| | Pit latrine | | - | - | 456.7 | 200.4 | 1,400.5 | 772.2 | 2,169.9 |
| | UDDT | | - | - | - | 677.6 | 1,400.5 | 772.2 | 2,169.9 |
| | Biogas | | - | - | - | - | 1,400.5 | 772.2 | 2,169.9 |
| | Septic tank | | - | - | - | - | - | 772.2 | 769.3 |
| | Public toilet with sewerage | | - | - | - | - | - | - | 2,169.9 |

# VI. Sanitation Program Design and Scaling Up

The Program Approach Analysis (PAA) aims to evaluate the link between different program approaches and eventual efficiency and impact of the sanitation options. The PAA compares indicators of sanitation program performance available from field site questionnaires and program documents, and also collects additional information from interviews with sanitation program managers and implementers. This chapter presents:

- The determinants of performance of sanitation programs from field sites and selected case studies.
- An overview of current practice in relation to sanitation program evaluation, to identify major gaps in understanding program performance, and to provide recommendations for improved monitoring and evaluation of sanitation programs.

The PAA is constrained by a lack of input data available from programs evaluated: several program reports are not available and the information is from forms filled out by the representatives of the organization or from secondary materials. The lack of information limits the number of programs that could be included in the study. The results of the analysis are interpreted taking into account setting-specific conditions which are partially responsible for the performance results; hence findings are not definitive, but instead illustrative and instructive.

## 6.1 PROGRAM APPROACH ANALYSIS FROM FIELD SITES

This section contrasts and compares the different indicators for assessment of program effectiveness in relation to different impacts of improved sanitation. The selected indicators will be used to estimate actual efficiency of sanitation programs in Chapter 7.

### 6.1.1 BASIC PROGRAM FEATURES FROM FIELD SITES

Table 32 shows basic program information in terms of starting and finishing coverage, and proportion of households reached by the program.

From the collected data, different sites have different sanitation coverage, and the sanitation coverage has been increased, especially in sites R1, R3 and U2. Different places have different growth rates, the most significant being Kunming rural site R1, where sanitation coverage has increased from 22 to 94%.

**TABLE 32:** SANITATION COVERAGE INFORMATION PER FIELD SITE

| Site | Households | | | Project starting coverage(%) | Project ending coverage (%) |
|---|---|---|---|---|---|
| | Interviewed in ESI survey | Reached by program | % | | |
| R1. Kunming | 151 | 54 | 35.8% | 21.8% | 94.0% |
| R2. Dali | 133 | 59 | 44.4% | 72.3% | 75.1% |
| R3. Qiubei | 171 | 75 | 43.9% | 69.1% | 94.5% |
| U1. Kunming | 120 | 59 | 49.2% | 78.2% | 83.0% |
| U2. Dali | 61 | 25 | 41.0% | 66.7% | 81.5% |
| U3. Qiubei | 72 | 19 | 26.4% | 74.1% | 77.8% |
| PU1. Kunming (Jinning) | 141 | 53 | 37.6% | 74.3% | 78.5% |
| PU2. Dali | 60 | 34 | 56.7% | 85.2% | 82.5% |

**TABLE 31:** BASIC FEATURES OF FIELD SITE SANITATION PROGRAMS

| Site | Toilet types | Implementation approach | Finance | Technical assistance, partnership and coordination |
|---|---|---|---|---|
| Kunming rural (Luquan) | Pit latrine | Demand-led | Household | Household is responsible for construction and management. |
| | Flush to septic tank | Traditional technology planning | Household/government | Household pays for water bill, sanitation construction cost and maintenance cost. |
| Kunming Urban | Flush to septic tank | Traditional technology planning | Household and government | Household pays for water bill, sanitation construction cost and maintenance cost. |
| | Flush to sewerage | Traditional technology planning | Government and household | Household pays for water bill, sanitation construction cost and maintenance cost, and local tax will cover the construction cost, and operation cost of WWTP. |
| Kunming Peri (Jinning) | Pit latrine | Demand-led | Household | Household is responsible for construction and management. |
| | UDDT | Supply-driven/project driven | Funds from project and matching funds from household | Swedish Royal Institute of Technology funded this project, Kunming City Environment Protection Bureau provided the technical support and was responsible for project management. |
| | Flush to septic tank | Traditional technology planning | Household/government | Household pays for water bill, sanitation construction cost and maintenance cost. |
| Dali Rural | Pit latrine | Demand-led | Household | Household is responsible for construction and management. |
| | UDDT | Supply-driven/project driven | Funds from project and matching funds from household | Dali City Environment Protection Bureau is responsible for technical support. The project is contracted to a construction unit, and the household members put in labor and time. |
| | Flush to septic tank | Traditional technology planning | Household/government | Household pays for the sanitation construction cost and responsible for sanitation maintenance. The government is responsible for waste management. |
| | Biogas | Supply-driven/project driven | 66.7% from government and 33.3% matching funds from household | Local forestry bureau provided technical support and financial support, household members put in labor and time. |
| | Pit latrine | Demand-led | Household/government | Household is responsible for construction and management. |
| Dali urban | Flush to septic tank | Demand-led, traditional technology planning | Household/government | Household covers the cost of the toilets, the construction unit is responsible for construction, the pipeline and other wastewater treatment systems are funded by government. |
| | Flush to sewerage | Demand-led, traditional technology planning | Local government and household | Household pays for water bill, sanitation construction cost and maintenance cost, and local tax will cover the construction cost, and operation cost of WWTP. |
| | Pit latrine | Demand-led | Household | Household is responsible for construction and management. |
| Dali peri-urban | Flush to septic tank | Demand-led, traditional technology planning | Household and government | Household covers the cost of the toilets, the construction unit is responsible for construction, the pipeline and the wastewater treatment systems are funded by government. |
| | UDDT | Supply-driven/project driven | Funds from project and matching funds from household | Dali city environmental protection bureau is responsible for building UDDT facilities. |
| | Pit latrine | Demand-led | Household | Household is responsible for construction and management. |
| Qiubei Rural | UDDT | Supply-driven/project driven | The project covered 80% of the construction costs; the voluntarily participating households covered the remaining 20%. | Several partners cooperated with each other. The main responsibilities are as follows: Yunnan Environment Development Institute was in charge of the project monitoring and inspection, Qiubei County Environment Protection Bureau, Xianrendong Primary School, Caihuaqing Primary School were in charge of the implementation. |
| | Biogas | Supply-driven/project driven | Project funding 66.7%, 33.3% matching funds by households | The project was contracted to a construction company, the energy office of Qiubei County Forestry Bureau was responsible for checking and accepting. |
| | Flush to septic tank | Traditional technology planning | Household and government | Household covered the cost of the toilets, the construction unit was responsible for construction, the pipeline and other wastewater treatment systems were funded by government. |
| | Pit latrine | Demand-led | Household | Household was responsible for construction and management. |
| Qiubei Urban | UDDT | Supply-driven/project driven | 80% funds from project and 20% matching funds from household | Swiss Reinsurance Company and German Embassy, Beijing financed this project, Yunnan Provincial Environment Protection Department provided the technical support and project monitoring. |
| | | Traditional technology planning | Household and government | Household covered the cost of the toilets, the construction unit was responsible for construction, the pipeline and the wastewater treatment systems were funded by government. |

Table 33 shows the main characteristics of different sanitation programs in eight sites. Program approaches are assessed from three perspectives: the implementation approach, the financing approach and the partnership approach, as follows.

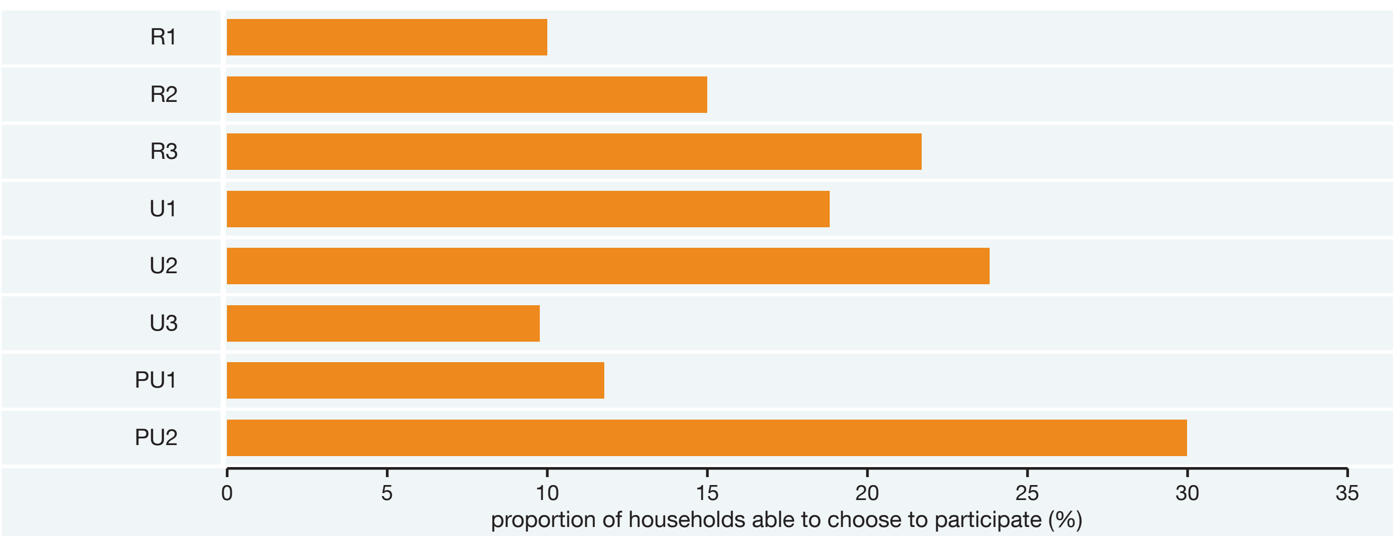
### 6.1.2 IMPLEMENTATION APPROACH

In rural areas, there are two main motivators for improvements in sanitation. One is household self-motivation, where (usually) the pit latrine is voluntarily constructed by the household. In this sense it is autonomous and demand-led. The technology is simple, and the human excreta is commonly reused in the fields. The other motivator for improved sanitation is supply-driven (project-driven). Under this implementation approach, the funds are commonly available, either from government subsidies or from donor projects' budgets. If the funds are from the government, the implementation approach is usually "top-down," in that limited consideration is taken of the local needs and conditions. The toilet type is chosen for households, but the households accept the project because it is almost free for them. If they are not active in the project, other projects may not be extended to their communities. Therefore, the actual use of the sanitation option may not be high, and hence the efficiency is affected. For example, there exist instances where the biogas toilet is constructed in households that do not raise any animals or where the climate is not very suitable for year-round biogas generation. Project-driven sanitation requires better project design and post-project management.

In urban areas, communal systems are a necessity, especially in densely populated areas or apartments. When houses in urban areas are constructed, the sanitation system is designed and constructed by a property developer. The household commonly chooses the sanitation facilities, such as specific toilet hardware. However, it is not the household's choice whether it is connected to the sewerage system or not. In urban areas, the household covers the water bills and maintenance fee. The government will fund the wastewater treatment systems and other management costs. It could be said that this approach is partially demand-led from the household, as they demand more hygienic and comfortable sanitation facilities, including water flushing systems.

Figure 44 shows the proportion of households with choice to participate. In general, the rate of households who feel that they had a choice to participate in the projects is not very high. The highest voluntary participation rate is from Dali peri-urban areas, with a 30% voluntary participation rate; the lowest is from Qiubei City areas, with less than a 10% voluntary participation rate. This may be related to the top-down planning approach of government projects. Only a small part of the projects used participatory methods to understand customers' needs and opinions. In addition, shown in Annex Table H1, in most projects there are no other complementary activities. Only a small number of projects conducted supporting activities, such as carrying out health awareness education or provision of water. This may be related to the narrow scope of project design and limited project funding.

**FIGURE 44:** HOUSEHOLDS WHO STATED THEY HAD A CHOICE WHETHER TO PARTICIPATE OR NOT




Source: Annex Table H1

**FIGURE 45:** MORE THAN ONE SANITATION OPTION WAS GIVEN TO HOUSEHOLDS

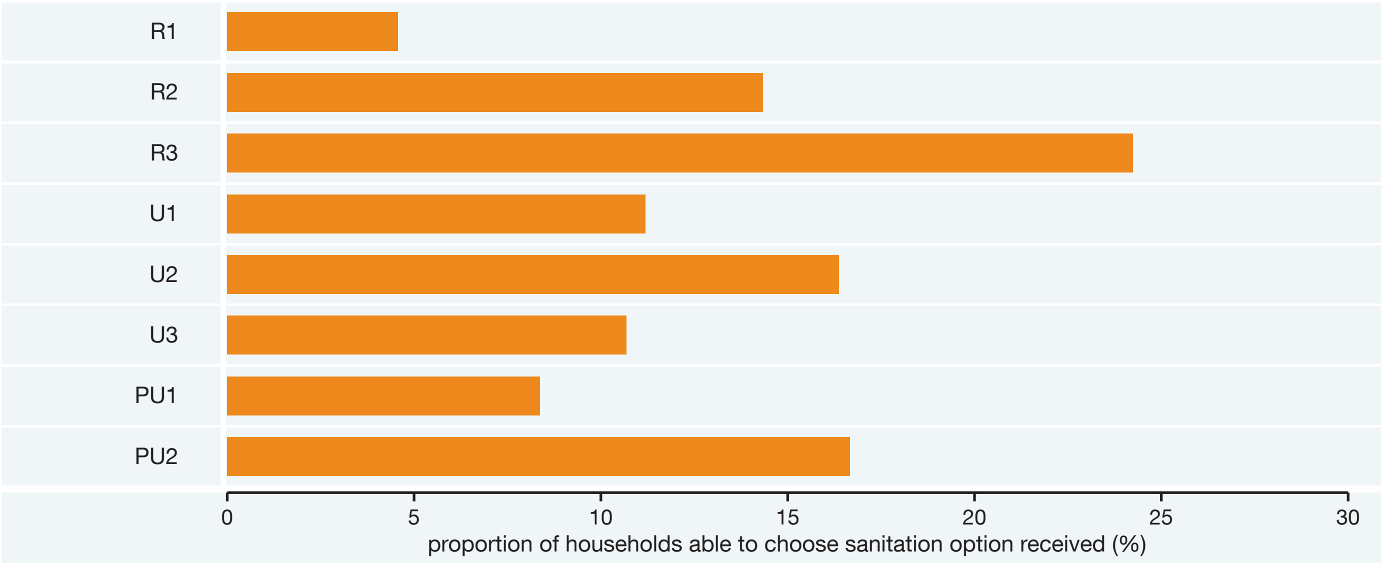
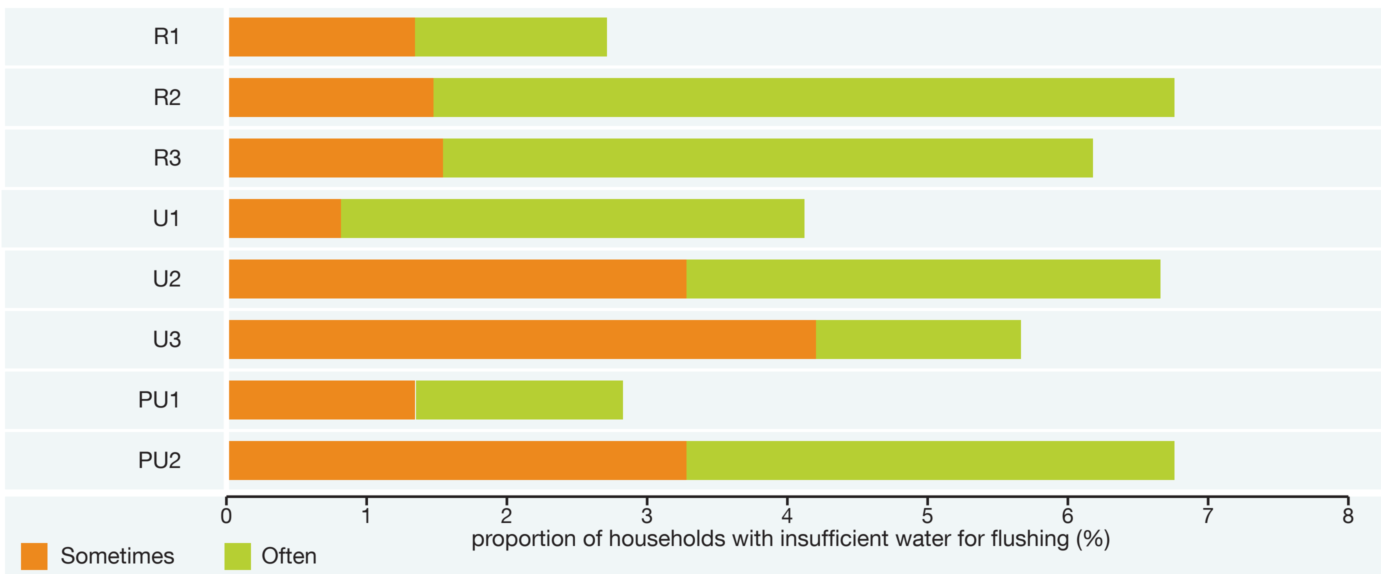



**FIGURE 46:** APPROPRIATE TECHNOLOGY – HOUSEHOLDS WITH INSUFFICIENT WATER FOR FLUSHING TOILETS




Source: Annex Table H3

Figure 45 shows that some projects provide options for users, but generally speaking, the percentage with different options on offer is not high. The highest proportion of households with choice of option is in the Qiubei rural area, with less than 25%, and the lowest is in Kunming city area, with less than 5%. This may be related to the project design. In fact, at the project design phase, the project content and the type of toilets have been agreed and the users are not involved in later project planning. Otherwise, users cannot get any support and it may be considered that they lack enthusiasm in the project, which may lead to no future projects in the village or local area. Thus, most farmers are passively involved in the project, and the result is that the utilization rate of some sanitation options is not high. For example, the utilization rate of UDDTs in Kunming peri-city area is relatively low, and some users use them for storage.

To assess the appropriateness of technology, an indicator was selected from the household survey which asked households with flush toilets whether they had enough water for flushing their toilets. Figure 46 shows that only a small number of users sometimes or often have insufficient water to flush toilets, while most users state they have adequate water to flush toilets. However, many cities like Kunming face water shortages, so water-saving and environment-friendly sanitation options should be alternatives, especially in water-scarce urban areas. A second indicator, the flooding of pit latrines, also indicated very few problems: less than 5% of households have pit flooding or pit overflow. During the rainy season, there is a higher proportion, but still less than 10 % of pit latrines overflow. Annex Table H3 presents more details.

### 6.1.3 FINANCING APPROACH

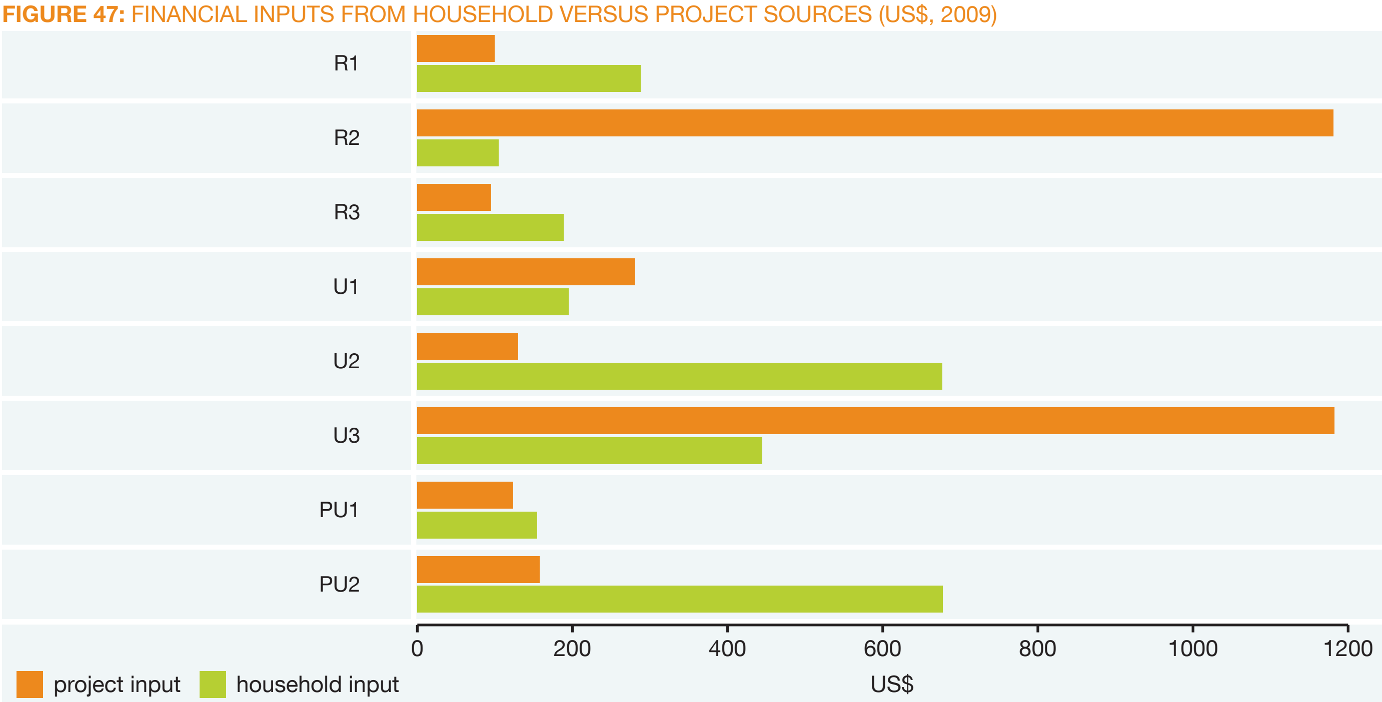
The investment for sanitation can come from many sources. A clear trend of sanitation programs is that a large part of funds come from projects or government subsidies, while the others need households to provide matching funds. Information on financing sources was already presented in Chapter 5.3. The main findings are presented briefly below.

Government funds: from central, provincial and local fiscal allocation of funds. The funds of biogas toilets are provided by the forestry department, poverty alleviation office, environmental protection bureaus or from women's federations, which are allocated from the central government for energy saving, poverty reduction, environmental protection, and standard of living improvement. The toilets flushing to sewerage or septic tanks are different, as the construction and operational cost of sewerage and wastewater treatment plants are relatively high and therefore funded by a government agency. Flushing toilets in urban areas are uniformly constructed by property developers when constructing the residential housing. The basic construction cost including the sewer, toilet and septic tank is included in the cost of the houses, to be eventually paid by the house owners.

International funds or national funds are provided by donors, foundations and non-government organizations, which are mainly by means of projects implemented in the communities or villages. The UDDT and biogas toilets are mainly project driven. The funds mainly come from external (foreign) donors. The UDDT project in the Qiubei urban site is funded by the Swiss Reinsurance Company and German Embassy, Beijing. The household contributes labor.

Figure 47 shows that the project financial support is different in different projects and regions, and the investments from projects vary greatly. The project investment in Dali rural areas and Qiubei City is the highest with more than 8,000 RMB per household. Qiubei rural areas receive significantly less, at under 700 RMB, and Kunming rural areas have the least investment from the project. The investment from households also varies among different regions and sanitation options. The investments from households are in the form of cash, labor and materials.

**FIGURE 47:** FINANCIAL INPUTS FROM HOUSEHOLD VERSUS PROJECT SOURCES (US$, 2009)



### 6.1.4 PARTNERSHIP APPROACH

In some cases, several parties make a concerted effort in order to achieve a common goal. This includes financing partnerships, implementation partnerships, coordination and management partnerships. In term of financing partnerships, the project may be co-funded by two or more organizations or groups. As an example, in urban Qiubei, the UDDT project is co-funded by the Swiss Reinsurance Company and German Embassy, Beijing, and implemented by the local construction department and households, with coordination by the Yunnan Provincial Environment Protection Department and Qiubei Environment Protection Bureau.

### 6.1.5 EFFECTIVENESS INDICATORS OF PROGRAMS IN FIELD SITES

Table 34 shows selected indicators from the program sites to illustrate the variation in the performance of different sanitation programs (refer to Annex Table H4).

**TABLE 34:** INDICATORS OF OVERALL PROGRAM EFFECTIVENESS IN FIELD SITES

| Variable | Rural sites | | | Urban sites | | | Peri-urban sites | |
|---|---|---|---|---|---|---|---|---|
| | R1 | R2 | R3 | U1 | U2 | U3 | PU1 | PU2 |
| Years of program | 4 | 5 | 4 | 3 | 2 | 3 | 4 | 5 |
| Approximate total investment cost per household (RMB yuan) | 2648 | 8782 | 1935 | 3249 | 5511 | 11115 | 1900 | 5702 |
| Main sanitation options adopted | UDDT, biogas | Septic/ UDDT | Biogas/ UDDT | Sewerage | Sewerage | Septic | Septic | Septic |
| % HH contribution to cost | 53.6% | 38.3% | 49.7% | 28.3% | 70.5% | 47.2% | 55.3% | 28.3% |
| % IMPROVED SANITATION HOUSEHOLDS, WITH MEMBERS SOMETIMES OR OFTEN, RESPONDING TO INTERVIEWER: | | | | | | | | |
| Using bushes for defecation | 3.3% | 4.6% | 10% | 0 | 0 | 1.4% | 0 | 5% |
| Using bushes for urination | 5.3% | 6.1% | 17% | 0 | 1.6% | 1.4% | 0.7% | 5% |
| Children using latrine | 24.5% | 13.5% | 18.1% | 10% | 24.6% | 22.2% | 29.1% | 6.7% |
| Children seen defecating in yard | 27.2% | 16.5% | 24% | 20% | 34.4% | 51.4% | 30.5% | 61.7% |
| Washed hands with soap yesterday | 94% | 94.7% | 85.4% | 95.8% | 100% | 86.1% | 97.2% | 93.3% |
| Washing hands after defecation | 88.1% | 69.9% | 55% | 75% | 78.7% | 77.8% | 90.1% | 71.7% |
| % IMPROVED SANITATION HOUSEHOLDS, OBSERVED BY INTERVIEWER: | | | | | | | | |
| Using well which is not covered | 8.6% | 0 | 29.8% | - | 13.1% | 6.9% | 13.5% | - |
| Using bucket to withdraw water from well | 17.2% | 6% | 11.7% | - | 18% | 9.7% | 22.7% | - |
| Pit latrine/septic tank within 10m of well | 0 | 40% | - | - | - | - | 0 | 0 |
| Pit latrine/septic tank within 20m of well | 0 | 60% | - | - | - | - | 0 | 50 |
| Signs of feces/waste at toilet | 23.8% | 15.8% | 12.3% | 4.2% | 29.5% | 4.2% | 34.8% | 0 |
| Signs of insects in toilet | 62.9% | 43.6% | 14.6% | 75.8% | 67.2% | 27.8% | 75.2% | 11.7% |
| Running water in or near toilet | 25.2% | 51.9% | 13.5% | 70.8% | 14.8% | 65.3% | 15.6% | 80% |
| Soap available for handwashing | 32.8% | 54.9% | 13.5% | 88.3% | 25% | 72.2% | 22.7% | 95% |

Data source: ESI household survey

To estimate actual economic performance, it is necessary to use selected key indicators of sanitation program performance to adjust the different benefits – health, water, access time and reuse – from the ideal efficiency level under highly performing options to get actual efficiency level under observed performance. Table 35 shows the selected key indicators, and presents the data. The extent of use of sanitation facilities, the hygienic state of sanitation facilities, the access time for sanitation, the extent of actual reuse of human excreta, the degree of satisfaction with key aspects of toilet facilities and the degree of satisfaction with the external environment: these variables can all show the effectiveness of the different types of sanitation.

Figure 48 shows that most of the users are satisfied with the sanitation facilities. In general, the households interviewed are satisfied with the sanitation options. The households in Kunming peri-urban and Dali city are less satisfied due to lack of improved private toilets constrained by limited land space.

Figure 49 shows that satisfaction of the households relating to the external environment does not vary a lot. Users in the Kunming City area feel very satisfied with the external environment, and users in the Qiubei Rural area feel the worst. The external environment in rural areas is still moderately poor quality, and the external environment in urban areas has been much improved.

Figure 50 shows that people in rural areas use for urination and defecation more frequently than people from city and peri-city areas. There are a few people using open areas shrubs for urination and defecation after improvement of sanitation and hygiene.

**TABLE 35:** SELECTED KEY INDICATORS FOR PROGRAM EFFECTIVENESS AVERAGELY CALCULATED FOR ALL THE SITES

| Impact | Indicator area |
|---|---|
| FOR QUANTITATIVE CBA TO ESTIMATE ACTUAL EFFICIENCY | |
| Health (sanitation) | 78% household members using improved toilet instead of previous unimproved option |
| Health (hygiene) | 75% households answered "yes" to washing hands after defecation<br>16% improved latrines in which there were signs of feces around toilet |
| Water treatment | 14% households treating water use non-boiling water treatment methods |
| Access time | 75% household members using own toilet instead of off-plot options |
| Reuse | 71% households with UDDT or biogas use the bi-products (fertilizer or biogas) |
| FOR QUALITATIVE ANALYSIS | |
| Intangibles | Average score of 3.6 (out of maximum score of 5) for all relevant satisfaction questions |
| External environment | Average score of 3.0 (out of maximum score of 5) for 2 external environment questions relating to sewage (visibility and smell) |

**FIGURE 48:** SATISFACTION LEVEL TO SANITATION OPTIONS (5 = VERY SATISFIED; 0 = DISSATISFIED)

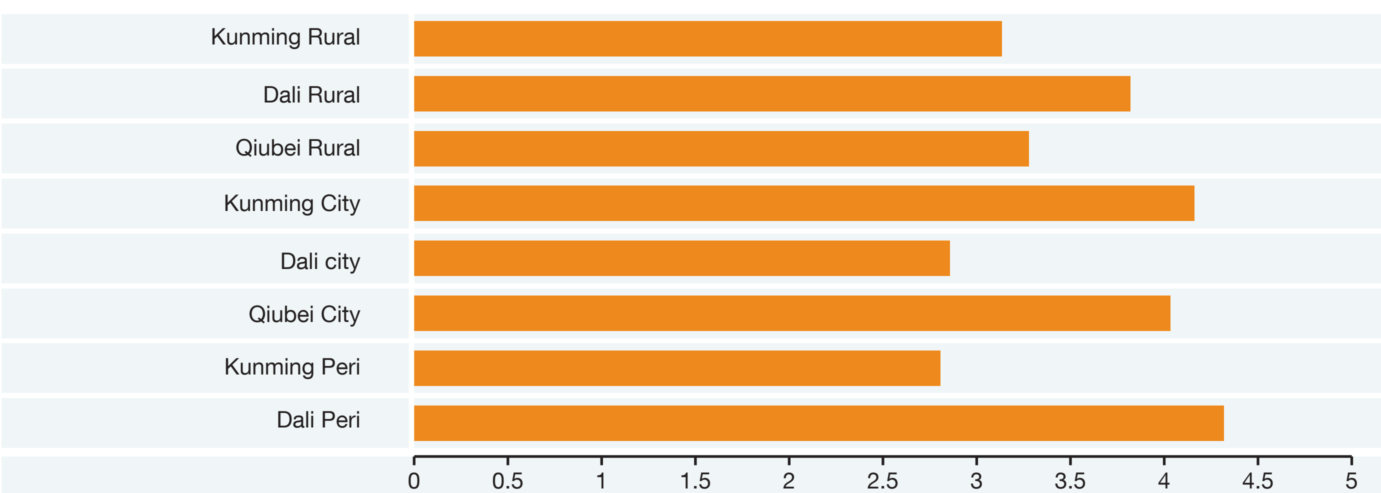


**FIGURE 49:** THE SATISFACTION LEVEL TOWARDS THE EXTERNAL ENVIRONMENT (5 = VERY SATISFIED; 0 = DISSATISFIED)

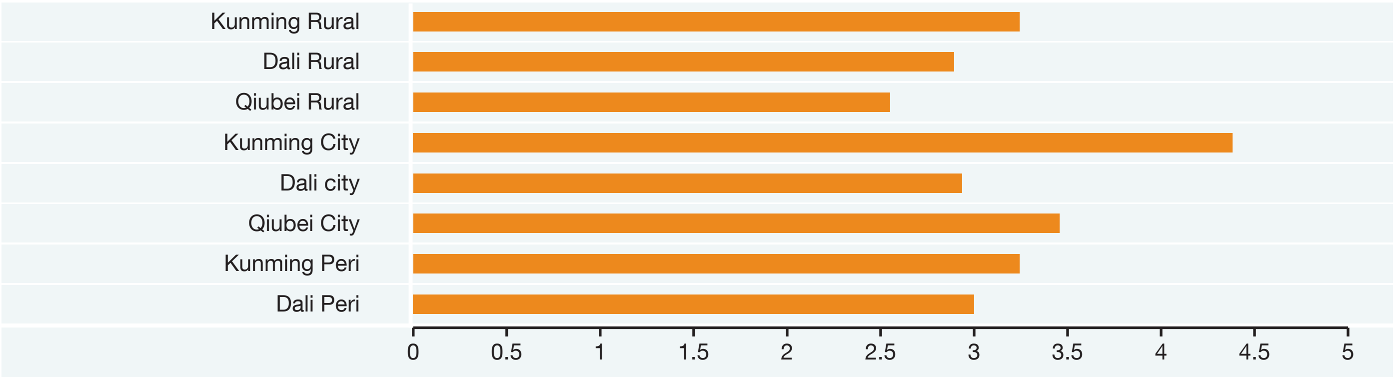



**FIGURE 50:** PROPORTION OF HOUSEHOLDS WITH MEMBERS WHO SOMETIMES OR REGULARLY URINATE OR DEFECATE IN OPEN AREAS, PER SITE (%)

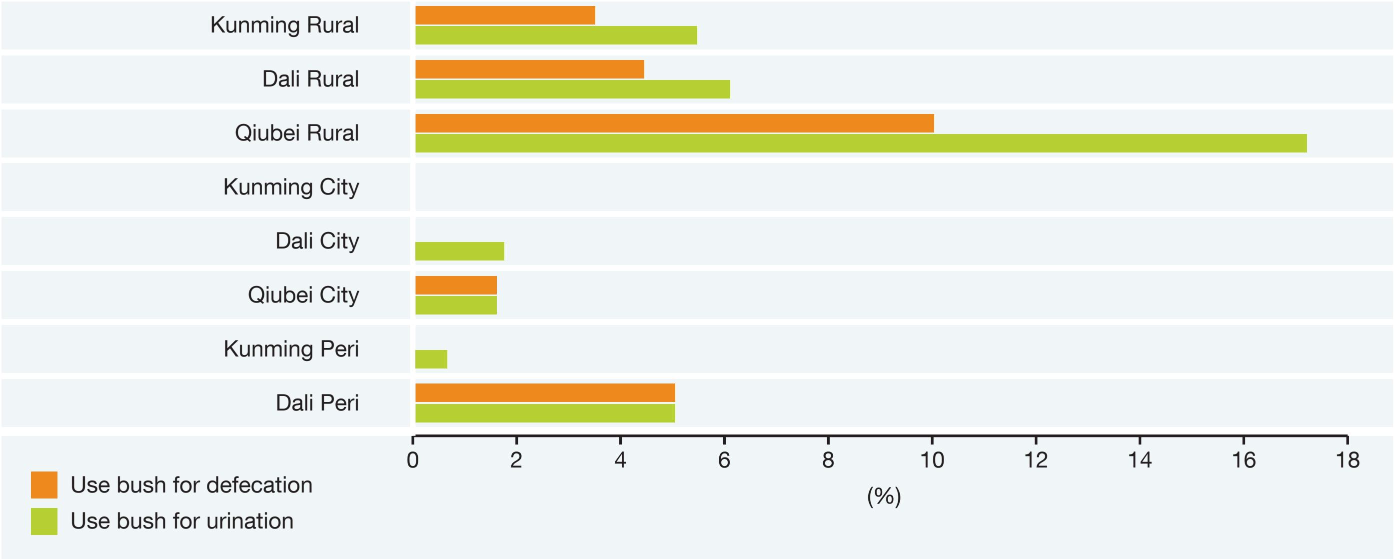



Figure 51 shows that the phenomenon of insects or animals in toilets is relatively common, and signs of feces relatively less common. In addition, the feelings of urban people towards the insects in their toilets are stronger than that in rural areas. There is another trend that the more developed the economy, the more people concerned about the sanitation status of the toilets.

Figure 52 and Annex Table H3 show that there are a small number of toilets (less than 10%) that often overflow during the rainy season. This shows that choosing appropriate sanitation options in the areas with a rainy season is very important to keep the environment free of pollution from human excreta.

Figure 53 shows that the utilization ratio of human excreta from rural areas is much higher than that of peri-city areas and city areas. It may be related to the fact that the households in rural areas make use of human excreta as fertilizer in their own fields or as the materials for raw biogas. With the increasing scaling-up of urbanization, and the change of land-use, many farms in city and peri-city areas become industrial factory buildings or commercial residential buildings. Some of the users do not cultivate their farms anymore, and use flushing toilets, so the rate of waste reuse is much lower.

## 6.2 PROGRAM APPROACH ANALYSIS FROM A BROADER ANALYSIS

Table 36 shows the basic features of sanitation programs and the basic interventions. The UDDT project in Puzhehei (Qiubei Urban) and the Biogas projects in Qiubei Rural are included in this section for further analysis (project numbers 1 and 4 in the table).

**FIGURE 51:** THE SANITATION STATUS INSIDE AND AROUND THE TOILET BUILDING/ROOM

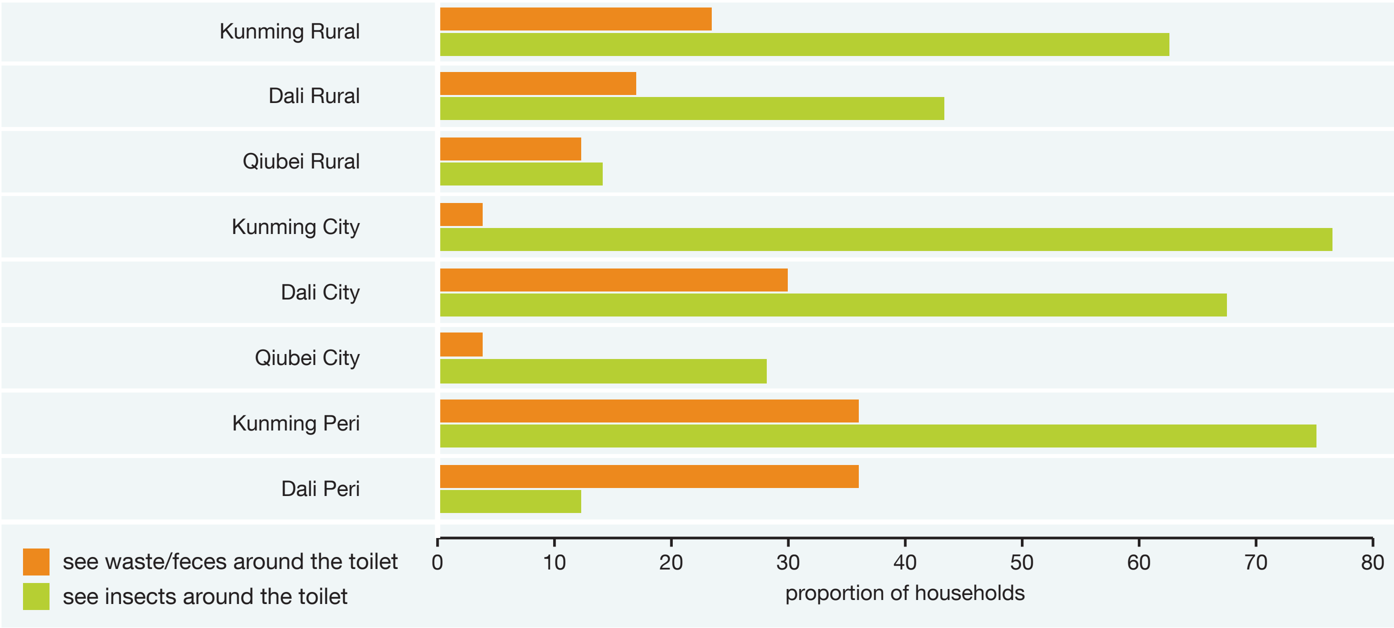



**FIGURE 52:** PROPORTION OF HOUSEHOLDS WITH PIT OFTEN OVERFLOWING DURING RAINY SEASON (%)

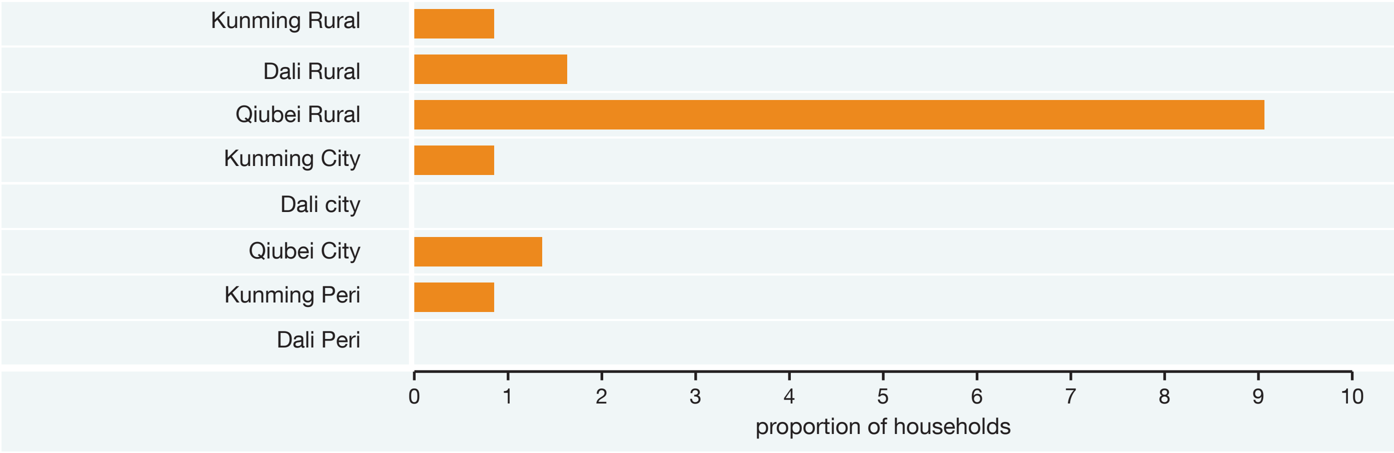
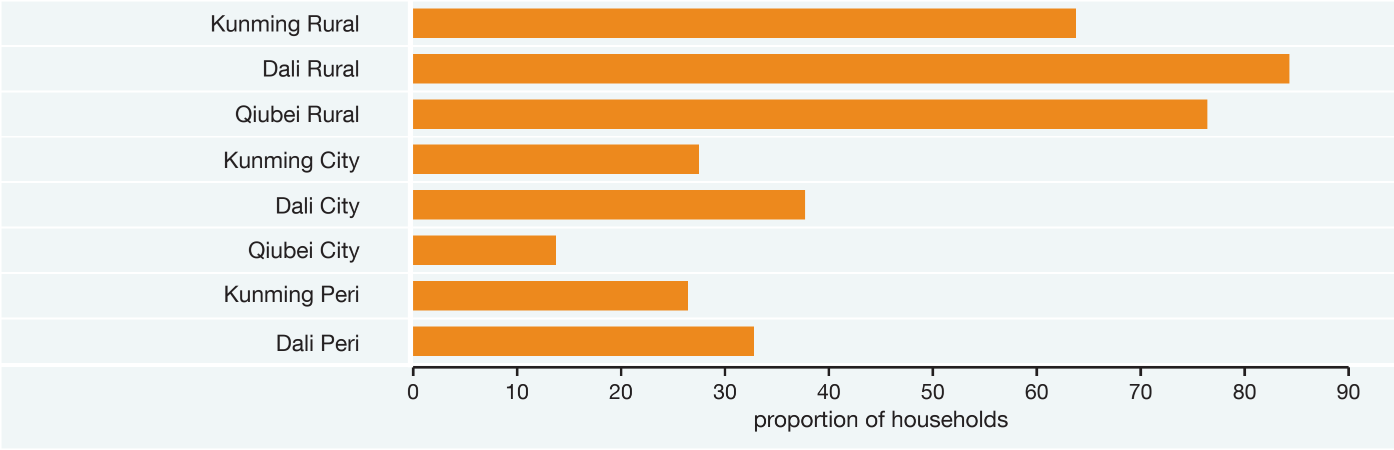



**FIGURE 53:** PROPORTION OF HOUSEHOLDS REUSING HUMAN EXCRETA (%)



The program information shows that participation, coordination, financing, etc. are related to sustainability. Here, the biogas project in Yanshan County of Wenshan Prefecture by Yunnan Green Environment Foundation serves as an example. For financing, Hongkong Changchun Society has funded the investment, program, and recurrent costs for the first two years. For technical assistance, the Energy Office, the Yunnan Forestry Department and the Yanshan Forestry Bureau are invited to be responsible for technical guidance. Yunnan Green Environment Foundation was responsible for coordination and project management. The users' participation was mobilized to contribute labor in the construction. Project monitoring was executed by the donor systematically. Hongkong Changchun Society was responsible for project monitoring.

**TABLE 36:** KEY INFORMATION ON SANITATION PROGRAMS

| No | Project name | Site location, urban/ rural | Provinces covered/ population/ households | Interventions | Households covered (receiving interventions) | Implementer | Funder | Unit cost | Funding mechanism | Start year | End year | Change in coverage over project period (%) | Utilization percentage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Puzhehei Upstream Eco-sanitation Project Phase I & II | Puzhehei Lake watershed, Qiubei County, Wenshan Prefecture, Yunnan Province, China | The Yi minority residents in lake adjacent to villages of Puzhehei watershed (population 40,000). | UDDT | 185 households | Yunnan Environment Development Institute | Swiss Reinsurance Company; German Embassy, Beijing | 1,080 | The project covered 80% of the construction costs; the voluntarily participating households covered the remaining 20%. | 2004 | 2008 | From 0 to 57% | 95% |
| 2 | Luoguo village Ameng Township Yanshan County (Rural) | Luoguo village Ameng Township Yanshan County (Rural) | 372 households in Luoguo village Ameng Township | Biogas | 300 households | Yunnan Green Environmental Development Foundation | Hongkong Changchun Society<br><br>2. Energy Office, Yunnan Forestry Department<br><br>3. Yanshan Forestry Bureau | 3,000 | 100% covered by project | 2008 | 2009 | From 0 to 96.4% | 100% |
| 3 | Lanping County City Wastewater Treatment program | City | Jinding Township, Lanping County (population of 26,000) | Flush toilet and waste water treatment plant | 26,000 people | Urban and Rural Construction Bureau Lanping County | Government | 49 million | The funds of waste water treatment plant: 70% of capital from treasury bonds, 20% from loans,10% matching funds by local government. | | 2009 | On-going | NA |
| 4 | Qiubei County Biogas program | Rural | 23,898 biogas toilets across 90 villages in 14 townships | Biogas | 23,898 households | Qiubei County Forestry Bureau | Yunnan Forestry Department | 1,500 | Project funding 66.7%, 33.3% matching funds by households | | 2000 | 2009 | From 0 to 29.95% |

**TABLE 37:** APPROACH OF SELECTED PROJECT

| Project | Participation | Coordination | Financing | Sustainability |
|---|---|---|---|---|
| Luoguo village Ameng Township Yanshan County Biogas program | User participation in contribution of labor | Training and management strengthened, Maintenance team for follow-up service | Full financing by donor | Needs assessment for appropriate technology/ monitoring, High adoption rate |

Based on a full investigation to understand the needs of the villagers, the local actual situation, as well as the feasibility of biogas toilets, they implemented the projects of constructing the biogas toilet, pig sty, and kitchen-improving in a comprehensive manner. The project attached great importance to the software components, such as training and management capacity of local users, focusing on the sustainability of projects. The project is also very popular as the utilization rate is 100%. The costs are all covered by the project. The total investment of the project is 1.24 million yuan (not including the farmers' own labor converting 345,000 yuan), of which 1.12 million was earmarked for the materials and design fees; 90,000 yuan to cover the labor costs, 30,000 yuan for establishing the service team of the project. The team consisted of two people, who were chosen by the villagers and trained. The team provides free technical guidance and maintenance services for the management, and comprehensive utilization two years after construction. Two years from now, if the biogas pool has any problems, users need to pay maintenance costs to the team.

## 6.3 ANALYSIS OF PROGRAM APPROACHES

### 6.3.1 THE IMPACT OF PROJECT DESIGN/ METHODOLOGY ON THE PROJECT EFFECTIVENESS

The program approaches affect the effectiveness of the programs. In the rural areas of China, the promotion of improved sanitation facilities is carried out mainly by the government. The approach of government programs tends to be top-down implementation and supplier-driven, not always considering local needs and conditions. As a result, users sometimes do not use or do not properly use the options, leading to reduced efficiency. In rural areas, some sanitation investment is "demand-led," with voluntary investment and construction by households. The technology is simple, and the human excreta is often reused in the fields. Due to the low cost and high utilization rate, the economic efficiency of pit latrines is high. In urban areas, a technology planning approach is common, with households connected to sewerage with flushing toilet. In these cases the sanitation is designed and constructed by a property developer, and commonly the buyer can choose the toilet type, but not the sanitation option itself.

Project design and implementation modality play an important role in the overall effectiveness and impact on households and hence efficiency. The project design is crucial for site selection considering whether there is scarcity of land, whether the option of the sanitation types can fit the local residents' habits, as well as local natural environmental conditions. In addition, the project should consider the users' ability to pay. As most of the projects need some matching funds from households and the poorer households do not have sufficient available cash, they may give up participating in the projects.

### 6.3.2 THE FACTORS DETERMINING SANITATION INTERVENTION CHOICES

There are many factors affecting users' choice of sanitation options, including users' economic levels, education levels, local natural conditions, hygiene habits, ethnicity and cultural factors, duration of life of sanitation options, accessibility to external support, and technical guidance and community services. As for the natural conditions, the 3-in-1 biogas toilets require a relatively mild climate for the amount of methane production to reach the required minimum. The cost of sanitation facilities and family economic conditions also impacts on the options of sanitation types. Compared with pit latrines and dry toilets, the construction cost of 3-in-1 biogas toilets is much higher. Without the full amount of subsidies from the government or donors, poor households could not invest in biogas toilets and thus would have to relinquish the chance to participate in the program. The users' social and cultural acceptability also affects the project performance. For example, the urine diverting dry toilets are eco-friendly toilets, but it requires the users to accept the facility and also spend time and effort managing it. It is challenged by the cultural acceptance. The utilization rate of UDDT in the suburb of Kunming is very low. Although UDDT has a high "ideal" benefit-cost ratio, the challenge to traditional habits in using and maintaining it and other factors make the acceptance very low and hence the "actual" benefit-cost ratio is low.

User preference of sanitation options is related mainly to the convenience and cleanliness of the sanitation options. Rural users also consider reuse of human excreta. Households with toilets hope to improve health, reduce pollution and use energy more efficiently. By analyzing the satisfaction level with the sanitation options, the results show the users are more concerned with convenience (especially for the elderly, and using toilets at night and on rainy days), disease prevention, hygiene (no smell and no insects), environmentally non-polluting, and the possibility of generating energy for home use.

### 6.3.3 THE REPLICABILITY OF THE SANITATION PROGRAMS

Different sanitation options have their advantages and limitations for wide-scale adoption, as summarized in Table 38. For example, the 3-in-1 biogas toilet requires a relatively mild climate (the most favorable temperature is 12 to 25 degrees Centigrade) and sufficient animal excreta available to add to the human excreta. The UDDT is more suitable for areas with a dry climate and low temperature, and especially in environmental protection areas such as reservoir catchments. The three-grid septic tank is not suitable for the areas with high water levels. Centralized wastewater treatment technology is not appropriate to extend to the sparsely populated mountainous areas, whose construction and operation costs require a minimum population density to make the investment worthwhile.

Biogas toilets and UDDTs have some advantages over other on-site sanitation options which are worth further consideration. First, 3-in-1 biogas toilets provide highly efficient organic fertilizer. The nutrients of the sludge from biogas toilets are comprehensive, after treatment, which can be reused as manure for aquaculture, fruit tree planting, and soil conditioning. It can be used to soak seeds, which can enhance the germination percentage and reduce the pests and disease. Human excreta can be treated safely through fermentation and drying, and if done properly, can reduce infectious diseases. The gas produced by the biogas toilet is used for cooking and lighting as an alternative, clean energy. The use of biogas relieves women from exposure to indoor smoke and from collecting firewood, contributing to improved health. Biogas as an alternative energy source, beside firewood, helps reduce the consumption of wood, and therefore protects forests and conserves water and soil. It is estimated that every cubic meter of gas can release

**TABLE G:** ADVANTAGES AND DISADVANTAGES OF DIFFERENT SANITATION OPTIONS

| Sanitation types | Advantages | Disadvantages |
|---|---|---|
| Pit latrine | • Low construction cost<br>• Simple technology<br>• Human excreta commonly extracted from the pit and reused as fertilizer | • Hygiene status of the toilet is often poor<br>• Often pollutes the environment, especially in the rainy season<br>• Human excreta is not safely treated, causing a higher health risk |
| Biogas | • Saves energy for lighting and cooking<br>• Provides highly efficient and safe organic fertilizers<br>• Saves money<br>• Reduces pollution to the environment<br>• Convenient, safe and healthy | • High construction cost<br>• Occupies space in homestead<br>• Limited by availability of animal manure<br>• Not suitable for cold climates<br>• Needs good post-phase management, including maintenance |
| UDDT | • Provides highly efficient and safe organic fertilizers<br>• Reduces pollution to the environment | • Not seen as convenient by users<br>• Smells if not properly maintained<br>• Needs time input of household and resources (such as rice husk/sawdust)<br>• Higher investment and recurrent cost than simple pit latrine |
| Water flushing toilet (with septic tank or sewerage) | • Clean<br>• Hygienic<br>• Convenient | • High construction cost and operational cost<br>• Needs a large amount of water<br>• Needs off-site wastewater treatment systems, and if not, black water released to the environment pollutes water bodies |

5,500,000 ~ 6,500,000 cal of heat. A 6-8 cubic meter biogas unit can save more than 2,000 kg of firewood a year (Chen Li, 2003).

The UDDTs also have several potential advantages, including pollution prevention, recycling what is often considered "waste" into usable and economically valuable nutrients, reducing the need for chemical fertilizers and thus contributing to ecological balance. The UDDTs can save water, and reduce the cost of fertilizer. Every person can excrete 25-50 kg of manure every year, containing 0.55 kg of nitrogen, 0.18 kg of phosphorous and 0.37 kg of calcium. Also, every adult produces 400-500 liters of urine annually, containing 4 kg of nitrogen, 0.4 kg of phosphorous and 0.9 kg of calcium. It respectively exists in the form of urea, phosphate and potassium ions, which are more conducive to being absorbed by plants. It is helpful for promoting ecological agriculture (Chen Li, 2003).

The pit latrine toilet is mainly constructed by the households themselves, which is demand-led. As the construction cost is low and the technology is simple, it is very popular in the rural sites. In addition, human excreta in the pit can be easily used for fertilizer on farmland. However, unless the excreta is appropriately hygienized and dried before application in the fields, there are health risks which due to health costs may lead to net negative impacts.

The construction costs of water-flushing toilets and conveyance systems are relatively high, usually with a long duration of life. It is convenient, and if waste is well isolated and treated then disease rates can be reduced. Therefore, water-based off-site sanitation systems have good potential for application in cities and towns. But the toilet requires more water to function. A water-flushing toilet consumes 2,000 liters of water per person per year (Chen Li et al, 2004). The water for flushing toilets can account for between one third and one half of domestic water use. The flushing water will mix with other less contaminating wastewater in the family, which increases the effluent volume. If it is further mixed with industrial wastewater and rain water, it is more costly to treat.

The project design should include sensitization and capacity-building of the users, and also a plan for management after the project has been completed and has withdrawn, in order to ensure the sustainability of the sanitation options delivered. In the process of promoting the sanitation project, it is important to select the technical sanitation options that reflect the local situation, such as the natural conditions, local residents' economic status, hygiene and living habits, and the willingness of residents to adopt the technology. In addition, it is crucial to follow up with hygiene education, awareness promotion, and monitoring since these can significantly increase the effectiveness and economic efficiency of the program.

In conclusion, having the appropriate project design is very important as it determines the efficiency of the sanitation interventions. First, it should take into account the local needs and willingness to pay. The household owners should have a variety of sanitation types and options to choose from. Second, project design should consider the hidden cost of projects, taking into account the fact that some sanitation options require higher spending on maintenance and operation costs, such as personnel, water and energy. Third, the subsidy element from government is important and should focus on software components, including strengthening the capacity and skills of local technical personnel and supporting the establishment of local maintenance teams, which improve overall project efficiency, impact and sustainability.

# VII. Efficiency of Improved Sanitation and Hygiene

This Chapter synthesizes the information presented in Chapters 4 to 6 to present sanitation option efficiency under both ideal and actual program conditions. Alongside the quantitative cost-benefit and cost-effectiveness ratios, non-quantified impacts are also presented. The chapter consists of four sections:

- Efficiency of sanitation interventions, compared with no sanitation option (Section 7.1)
- Efficiency of moving from improved sanitation options to other options "higher" up the sanitation ladder (Section 7.2)
- Contextualization of the results in a provincial context (Section 7.3)
- Overall cost benefit assessment (Section 7.4)

## 7.1 EFFICIENCY OF SANITATION AND HYGIENE IMPROVEMENTS COMPARED TO NO FACILITY

Economic analysis combines evidence on the cost and benefits of sanitation improvements already presented in earlier chapters, giving a number of alternative measurements of efficiency. Efficiency measures are presented in Table 39 for rural areas, Table 40 for urban areas, and Table 41 for peri-urban areas, under an analytical time horizon of 20 years.

### 7.1.1 RURAL SITES

Table 39 shows that all the sanitation options in rural areas have a high level of efficiency. The main sanitation options in rural areas include shared, pit latrine, UDDT, biogas di-

**TABLE 39:** RURAL AREA EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET" (COST DATA IN US$, YEAR 2009)

| Efficiency measure | Scenario | Shared | Pit latrine | UDDT | Biogas | Septic tank |
|---|---|---|---|---|---|---|
| Field sites including per option[1] | | R2, R3 | R1,R2, R3 | R2 | R2 | R1,R2, R3 |
| No. of observations (households) | | 14 | 118 | 14 | 43 | 214 |
| COST-BENEFIT MEASURES | | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 10.2 | 12.9 | 14.9 | 11.4 | 7.6 |
| | Actual | 6.0 | 8.5 | 9.4 | 6.9 | 4.7 |
| Internal rate of return (%) | Ideal | > 100% | > 100% | > 100% | > 100% | > 100% |
| | Actual | > 100% | > 100% | > 100% | > 100% | > 100% |
| Payback period (years) | Ideal | <1 year | <1 year | <1 year | <1 year | <1 year |
| | Actual | <1 year | <1 year | <1 year | <1 year | 1.4 |
| Net present value ($) | Ideal | 484.9 | 758.6 | 1,079.5 | 1,110.1 | 916.6 |
| | Actual | 262.4 | 473.2 | 652.5 | 637.2 | 520.5 |
| COST-EFFECTIVENESS MEASURES | | | | | | |
| Cost per DALY averted ($) | Ideal | 160.6 | 207.7 | 155.8 | 190.1 | 296.2 |
| | Actual | 284.9 | 413.9 | 271.6 | 348.6 | 478.8 |
| Cost per case averted ($) | Ideal | 1.4 | 1.8 | 1.4 | 1.7 | 2.6 |
| | Actual | 2.5 | 3.1 | 2.4 | 3.2 | 4.3 |
| Cost per death averted ($) | Ideal | 2,903 | 3,750 | 2,818 | 3,430 | 5,335 |
| | Actual | 5,151 | 6,277 | 4,909 | 6,287 | 8,623 |

[1] See Annex Tables for site-specific information. Figures reflect unweighted average of three rural sites.

gesters, and private septic tanks. In comparison with "no toilet," UDDT has the best ideal efficiency of BCR at 14.9 and actual BCR of 9.4, while private septic tanks in rural areas have the lowest BCR with significant value in an ideal program situation of 7.6 and under actual program effectiveness of 4.7. BCR of private pit latrines also reached 12.9 in terms of ideal efficiency and actual efficiency of 8.5. For all technologies except septic tanks, the payback period is less than one year. The actual net present value (NPV) of UDDT is the highest, reaching US$652.5, a little higher than that of 3-in-1 biogas units, and more than two times higher than that of shared toilets.

There are noteworthy differences in economic performance for pit latrines among the three rural sites, shown in Figure 55. The actual BCR of pit latrines ranges from 9.4 in Dali to 8.8 in Qiubei to 6.6 in Luquan (near Kunming).

For the health efficiency measures, the top-ranked interventions are UDDT, shared toilet and biogas. There is little difference among the options in term of health cost-effectiveness. UDDTs have a cost per DALY averted of US$155.8, cost per case averted of US$2.4, and cost per death averted of US$4,908.7.

In rural areas, the findings of the FGDs strengthen the conclusion of low acceptance of UDDT even though it has the highest efficiency performance under ideal conditions. Improved pit latrines are mostly preferred in rural areas, followed by biogas as the second choice.

Most of the farmers interviewed in the FGDs thought that the improved private pit-latrine is more suitable, it can be used for storing excreta/compost, and it is convenient to

**FIGURE 55:** BENEFIT-COST RATIO OF PIT LATRINES IN THREE RURAL SITES

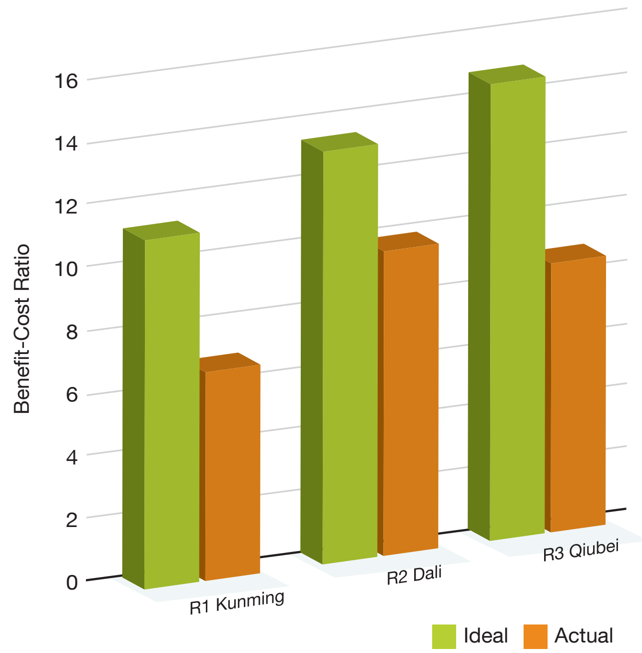
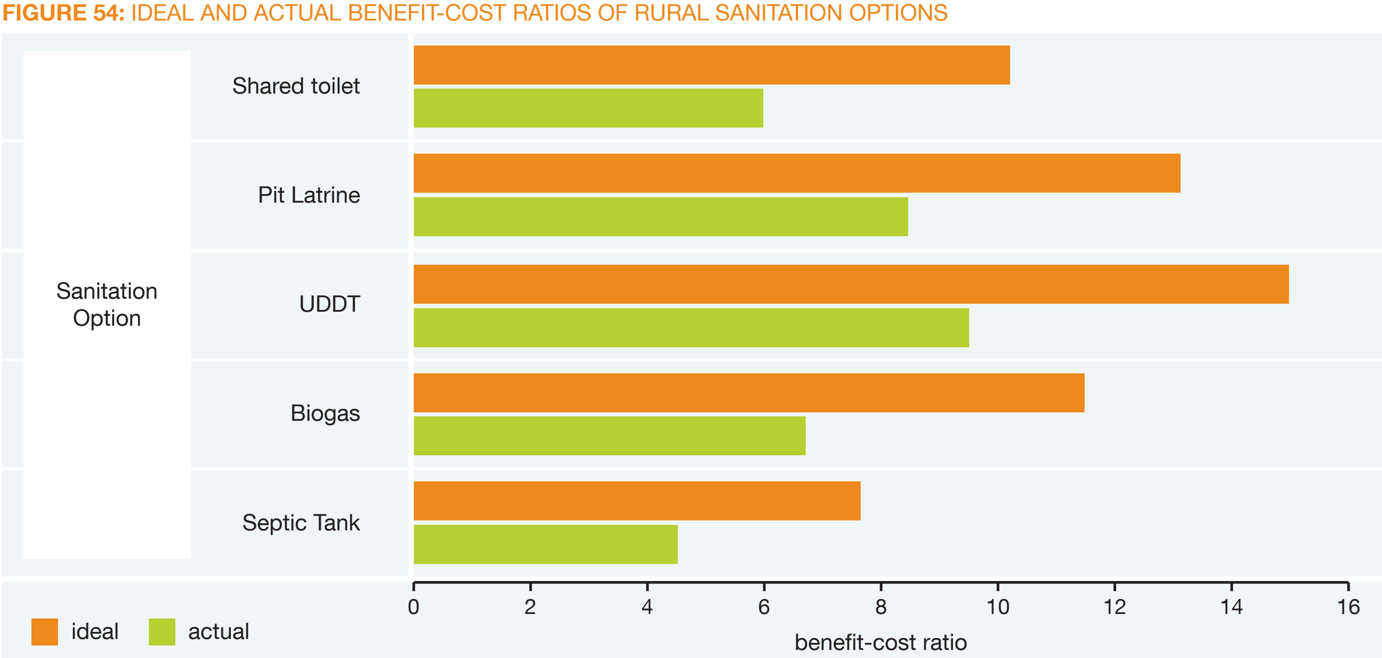
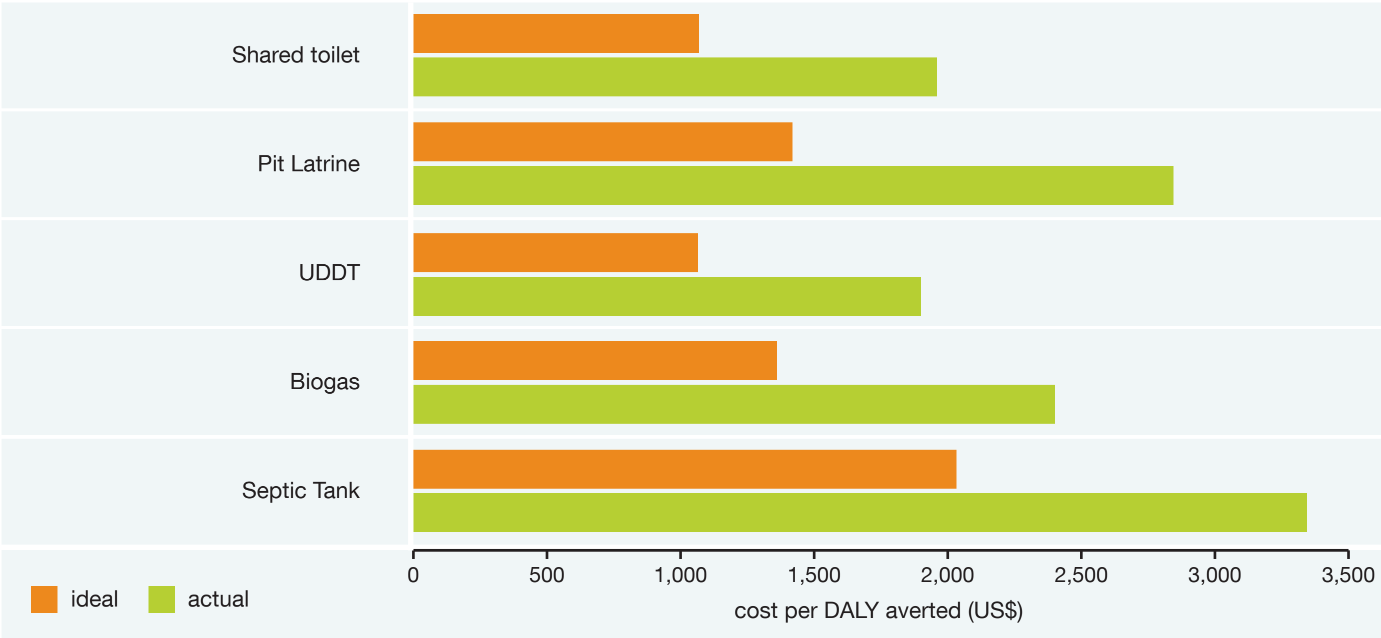



**FIGURE 54:** IDEAL AND ACTUAL BENEFIT-COST RATIOS OF RURAL SANITATION OPTIONS




Figures reflect unweighted average of three rural sites.

**FIGURE 56:** COST PER DALY AVERTED FOR RURAL SANITATION OPTIONS (US$, YEAR 2009)




clean. As a second choice they preferred to use the 3-in-1 biogas unit. UDDT (Urine Diversion Dehydration toilet) was listed as their last choice; most of the families did not like it due to the poor quality and radical change of habits in using and maintaining the toilet. Families without a toilet expected to have a public toilet or shared toilet within the community first, and then they expected to have an improved private pit latrine.

### 7.1.2 URBAN SITES

In urban areas, sanitation options are mainly flush toilet connected to septic tank and sewerage as well as public toilets. Some cities at county level like Qiubei have not yet built a sewerage system, and therefore the main options are septic tanks together with shared and pit latrines. A city at provincial level like Kunming has mostly sewerage, septic tanks, and public toilets connected to sewerage.

Table 40 shows that for urban areas, the BCR of private latrines is the highest with an ideal BCR at 7.9 and actual BCR at 5.4. Toilets with septic tanks have ideal and actual BCR of 4.2 and 2.8, respectively. In comparison, flush private toilets with sewerage have less favorable BCR at 2.7 (ideal) and 1.9 (actual). The lower ratios are mainly due to the high construction cost, leading to higher annualized costs per household than other sanitation options. Flush toilets with sewerage connection have an actual IRR of 36% and actual PBP of 4.4 years. In comparison, flush toilets connected to septic tanks have a higher actual IRR of 77% and lower actual PBP of 2.6 years. The net present value under actual conditions ranges from US$157 for shared to US$402 for UDDT.

For NPV, the four sanitation options are ranked from public flush toilet, with the highest value, followed by private pit latrine, private flush toilet with septic tank and private flush toilet with sewerage (the shared and UDDT are not calculated due to the small sample). In terms of cost-effectiveness, the four sanitation options in urban areas are in the same order as actual NPV. Cost-effectiveness measures range from US$304.93 per DALY averted for public toilet to US$886.4 per DALY averted for septic tank to US$1,385.3 per DALY averted for sewerage. Other less common options found in urban areas – shared toilet and UDDT - also have potentially favorable efficiency, with a BCR ranging from 3.9 to 5.7, respectively.

### 7.1.3 PERI-URBAN SITES

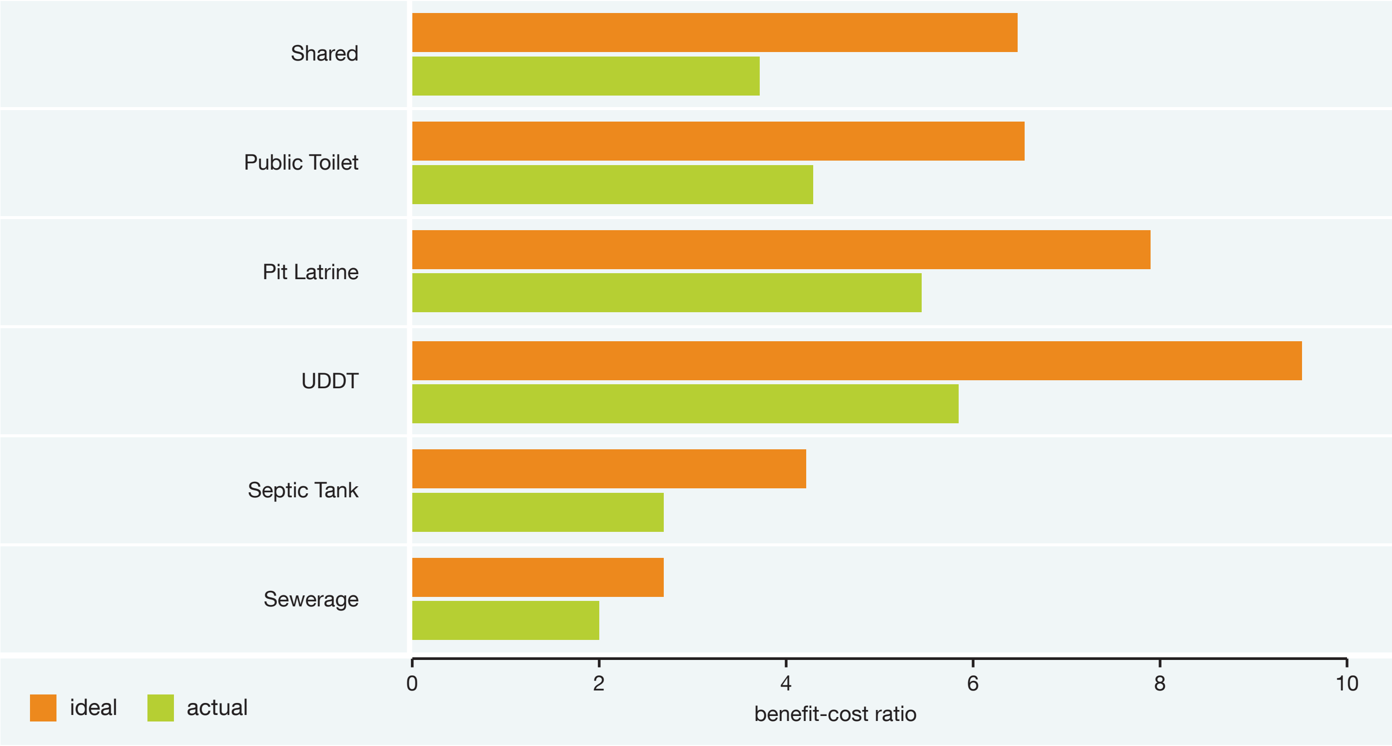
According to the survey results in peri-urban areas in Table 41, the main sanitation options are shared pit latrines, private pit latrines, UDDT and private septic tanks. The sanitation options in peri-urban areas have very different economic performances than rural areas. UDDT and private latrines have the most favorable efficiency indicators.

**TABLE 40:** URBAN AREA EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET" (COST DATA IN US$, YEAR 2009)

| Efficiency measure | Scenario | Shared | Public toilet | Pit latrine | UDDT | Septic tank | Sewer-age |
|---|---|---|---|---|---|---|---|
| Field sites including per option | | U3 | U2 | U2, U3 | U3 | U1, U2, U3 | U1, U2 |
| No. of observations (households) | | 2.0 | 16.0 | 26.0 | 3.0 | 156.0 | 44.0 |
| COST-BENEFIT MEASURES | | | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 6.5 | 6.7 | 7.9 | 9.5 | 4.2 | 2.7 |
| | Actual | 3.9 | 4.5 | 5.4 | 5.7 | 2.8 | 1.9 |
| Internal rate of return (%) | Ideal | >100% | >100% | >100% | >100% | 3.4 | 0.8 |
| | Actual | >100% | >100% | >100% | >100% | 0.8 | 0.4 |
| Payback period (years) | Ideal | <1 year | <1 year | <1 year | <1 year | 1.6 | 2.4 |
| | Actual | 1.2 | <1 year | <1 year | <1 year | 2.6 | 4.4 |
| Net present value ($) | Ideal | 298.8 | 495.4 | 448.6 | 725.8 | 469.6 | 355.6 |
| | Actual | 157.3 | 305.0 | 285.4 | 401.7 | 262.0 | 180.6 |
| COST-EFFECTIVENESS MEASURES | | | | | | | |
| Cost per DALY averted ($) | Ideal | 193.6 | 334.9 | 317.1 | 193.3 | 531.8 | 866.3 |
| | Actual | 322.7 | 558.1 | 528.5 | 322.2 | 886.4 | 1,385.2 |
| Cost per case averted ($) | Ideal | 1.9 | 3.0 | 2.9 | 1.9 | 5.1 | 8.2 |
| | Actual | 3.2 | 5.0 | 4.8 | 3.2 | 8.4 | 13.0 |
| Cost per death averted ($) | Ideal | 3,499 | 6,152 | 5,798 | 3,497 | 9,579 | 12,251 |
| | Actual | 5,831 | 10,253 | 9,664 | 5,829 | 15,964 | 24,964 |

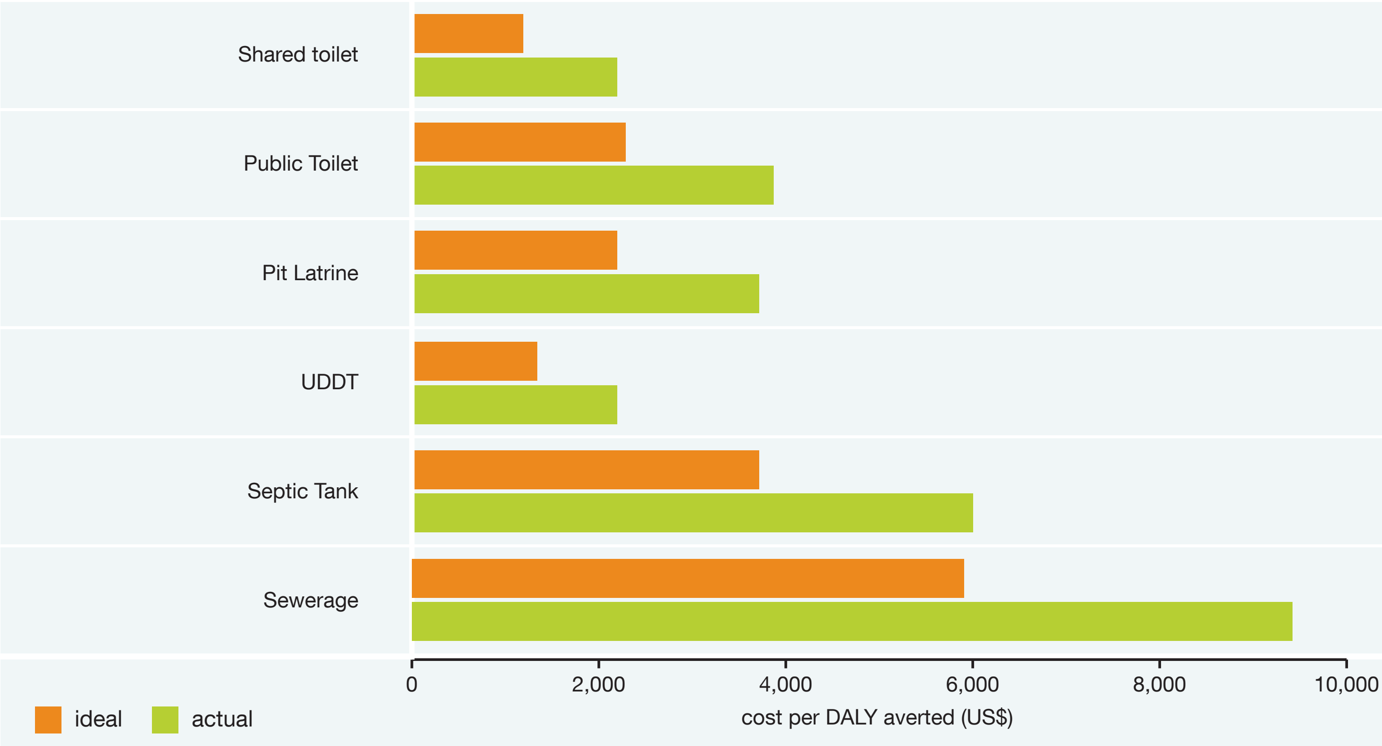
Figures reflect unweighted average of three urban sites.

**FIGURE 57:** BENEFIT-COST RATIO OF SANITATION OPTIONS IN URBAN AREAS.




For specific sites, the BCR of sewerage and septic tanks in the urban areas of Kunming, Dali, and Qiubei has little difference (see tables in annex). Figures reflect unweighted average of three urban sites.

**FIGURE 58:** COST PER DALY AVERTED FOR URBAN SANITATION OPTIONS (US$, YEAR 2009)




Figures reflect unweighted average of three urban sites.

UDDT and private latrines have an efficiency ratio of 5.3 and 5.0 respectively. The actual BCR of septic tanks is at 2.7 as the minimum among the four sanitation options next to the shared option of 3.9. There is also a big difference between ideal and actual benefit cost ratios.

For IRR and PBP, the four sanitation options are ranked as UDDT, pit latrines, septic tanks and shared. Septic tanks have relatively low BCR and IRR compared to shared toilets, but its actual NPV is higher than that of the toilets, reaching US$245.9.

For cost-effectiveness measures, UDDT is ranked first among the four sanitation options, followed by shared, pit latrine and septic tank. The cost-effectiveness measures for the same sanitation option are higher than those in rural areas, ranging from US$461 per DALY averted for UDDT to US$860 per DALY averted for septic tanks.

Urban families using private wet pit or flush toilets were generally satisfied with the comfort of current sanitation options. However, for those families who used public toilets, most of them thought that using a private toilet can provide more comfort; they expected to get a flush toilet or wet pit. In the peri-urban areas, families using public toilets preferred the flush toilets–they anticipated installing a flush toilet if there was a septic tank or sewerage system. In peri-urban areas, public facilities for septage management for septic tanks, and sewerage, were not included in urban planning, and sanitation options used in peri-urban areas are very similar to those in rural areas.

## 7.2 EFFICIENCY OF ALTERNATIVES FOR MOVING UP THE SANITATION AND HYGIENE LADDER

It is important and practical to analyze the efficiency of alternatives for moving up the sanitation ladder in Yunnan Province, a context where sanitation coverage in still low in rural areas and in future years many households may be faced with improving their current toilet option. The long-term inputs from the government and other donors have helped the rural population to have better sanitation and hygiene. Many rural families have stopped practicing open defecation. On the other hand, many sanitation options currently used are not fully improved from both health and environmental perspectives, thus requiring upgrading. Hence, an examination of the efficiency of alternative options for moving up the sanitation and hygiene ladder

**TABLE 41:** PERI-URBAN AREA EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET" (COST DATA IN US$, YEAR 2009)

| Efficiency measure | Scenario | Shared | Pit latrine | UDDT | Septic tank |
|---|---|---|---|---|---|
| Field sites including per option | | PU1, PU2 | PU1, PU2 | PU1, PU2 | PU1, PU2 |
| No. of observations (households) | | 71.0 | 29.0 | 24.0 | 75.0 |
| COST-BENEFIT MEASURES | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 6.1 | 7.6 | 8.7 | 4.2 |
| | Actual | 3.9 | 5.0 | 5.3 | 2.7 |
| Internal rate of return (%) | Ideal | >100% | >100% | >100% | >100% |
| | Actual | >100% | >100% | >100% | >100% |
| Payback period (years) | Ideal | <1 year | <1 year | <1 year | 1.6 |
| | Actual | 1.4 | 1.1 | <1 year | 2.8 |
| Net present value ($) | Ideal | 285.9 | 447.6 | 640.4 | 469.6 |
| | Actual | 159.9 | 271.8 | 354.0 | 246.0 |
| COST-EFFECTIVENESS MEASURES | | | | | |
| Cost per DALY averted ($) | Ideal | 309.8 | 317.2 | 505.3 | 516.6 |
| | Actual | 516.3 | 528.6 | 461.0 | 860.9 |
| Cost per case averted ($) | Ideal | 2.8 | 2.9 | 2.5 | 4.7 |
| | Actual | 4.7 | 4.8 | 4.2 | 7.9 |
| Cost per death averted ($) | Ideal | 5,675 | 5,822 | 5,063 | 9,448 |
| | Actual | 9,459 | 9,704 | 8,438 | 15,747 |

Figures reflect unweighted average of two peri-urban sites.

**FIGURE 59:** BENEFIT-COST RATIOS OF PERI-URBAN SANITATION OPTIONS

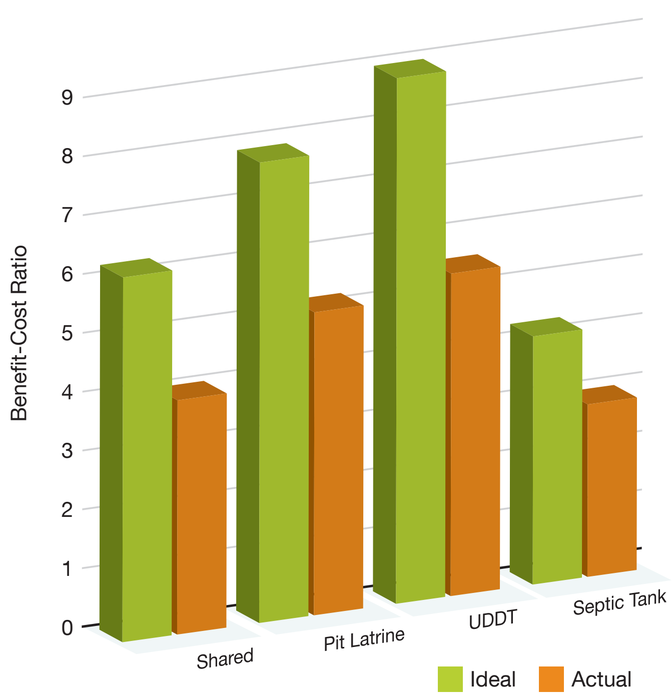
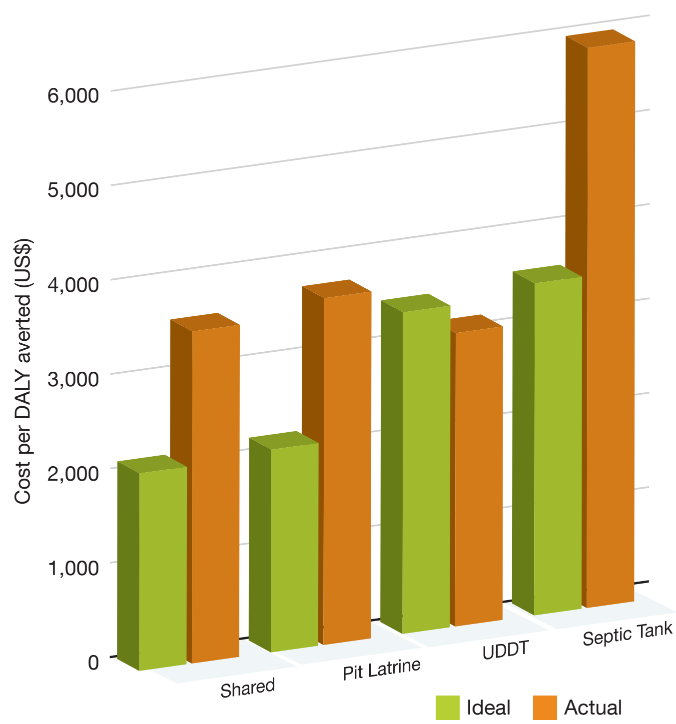



**FIGURE 60:** COST PER DALY AVERTED OF PERI-URBAN SANITATION OPTIONS (US$, YEAR 2009)




Figures reflect unweighted average of peri-urban sites.

is important to provide evidence to policy makers and development agencies as well as for households' own autonomous investment decisions. Below, representative sites for rural and urban areas are selected to illustrate the issues.

### 7.2.1 RURAL SITE (QIUBEI)

In the Qiubei rural area, shared toilet and pit latrines are widely used, so they are the starting points for an efficiency analysis of alternatives for moving up the sanitation and ladder. Table 42 shows that in rural areas, the efficiency of improved sanitation moving from shared to private pit latrine, UDDT and biogas are 2.89, 0.72 and 1.67 respectively. The efficiency of the UDDT alternative to shared is less than 1, and the NPV is negative, but the health cost-effectiveness of the UDDT alternative to shared is favorable with a cost per DALY averted of US$632. The incremental efficiency of improved pit latrines is significant in comparison with the "shared." Other sanitation options are not much different from pit latrines, so the incremental BCR of moving from pit latrine is not significant with a benefit cost ratio of less than one; but cost effectiveness measures range from US$448 per DALY averted for moving from shared to biogas, to US$1,084 per DALY averted for moving from pit latrines to septic tanks.

### 7.2.2 URBAN SITE (KUNMING)

Kunming, as the provincial capital of Yunnan Province, has a developed sanitation system with private flush toilets connected to septic tanks and sewerage. There are some flush toilets connected to septic tanks only. Although there are public toilets in the city, the analysis on the efficiency of alternatives for moving up the sanitation ladder focuses on the private flush toilets due to insufficient sample of public toilets in Kunming city.

Table 43 shows that in urban areas, the economic performance of moving from septic tanks (without septage management) to sewerage is not reasonable and feasible, but the health impacts of sewerage are potentially significant. The cost effectiveness ratio for moving from septic tanks to sewerage is US$6,177 per DALY averted.

## 7.3 SCALING UP RESULTS FOR PROVINCIAL POLICY MAKING

The ultimate use of this study is not only the improvement of sanitation decision making in the field sites of the study, but also in Yunnan province more generally. Also, given this is the first study of its kind throughout China, it is relevant to assess national policies in light of the study results. Therefore, how well do the field sites reflect different decision making contexts in Yunnan Province and China in a broader sense?

First, the field sites were selected to be representative of different geo-physical, climatic, demographic and socio-economic contexts in the province. Three different zones were represented: Northern, Central and Southern. In each zone, rural and urban sites were represented, and in two zones (Central and Northern) also peri-urban sites.

**TABLE 42:** RURAL AREA EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARING DIFFERENT POINTS ON THE SANITATION LADDER (QIUBEI RURAL SITE)

| Efficiency measure | Moving from shared to | | | Moving from pit latrine to | | |
|---|---|---|---|---|---|---|
| | Pit latrine | EcoSan UDDT | Biogas | EcoSan UDDT | Biogas | Septic + STF |
| COST-BENEFIT MEASURES | | | | | | |
| Benefits per US$ input ($) | 3.8 | 4.5 | 7.3 | 4.5 | 5.0 | 2.1 |
| Internal rate of return (%) | >100% | >100% | >100% | >100% | >100% | 40% |
| Payback period (years) | 1.2 | <1.0 | <1.0 | <1.0 | 1.6 | 3.9 |
| Net present value ($) | 164 | 270 | 339 | 270 | 315 | 142 |
| COST-EFFECTIVENESS MEASURES | | | | | | |
| Cost per DALY averted ($) | na | 325 | 230 | 325 | 335 | 557 |
| Cost per case averted ($) | na | 3.1 | 2.2 | 3.1 | 3.2 | 5.3 |
| Cost per death averted ($) | na | 5,840 | 4,139 | 5,840 | 6,026 | 10,010 |

Note: na: not calculated due to improved pit latrine assumed to have the same health impact as improved shared latrine.

**TABLE 43:** URBAN AREA EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARING DIFFERENT POINTS ON THE SANITATION LADDER

| Efficiency measure | Scenario | Moving from septic tank to sewerage |
|---|---|---|
| COST-BENEFIT MEASURES | | |
| Net present value ($) | Ideal | (1,453.6) |
| | Actual | (1,358.1) |
| COST-EFFECTIVENESS MEASURES | | |
| Cost per DALY averted ($) | Ideal | 6,176.8 |
| | Actual | 9,617.9 |
| Cost per case averted ($) | Ideal | 59.1 |
| | Actual | 92.0 |
| Cost per death averted ($) | Ideal | 110,636 |
| | Actual | 172,273 |

Table 44 shows the characteristics of the eight field sites based on climatic, social group, population size, economic and sanitation features.

The sites are diverse in terms of the climatic, geographic, cultural and economic characteristics. Field sites included populations living in valleys or by lakesides to mountainous, hard to reach locations. The climate varied from a low-altitude climate, monsoon climate to a mountainous climate with a mean annual temperature ranging from 5 degrees Celsius in the north to 24 degrees Celsius in the south. Economically, the income per capita differs by more than ten-fold, ranging from US$219 to US$2,410 per year. Urban centers range from small towns of 50,000 to the provincial capital of 3.2 million inhabitants, and rural areas range from villages of 200 to villages near towns of 10,000 inhabitants. This diversity has imposed challenges for government stewardship capacity in sanitation and hygiene scaling up, as it requires different program approaches as well as technical options for different locations.

In rural lakeside and plain areas, it's difficult to maintain UDDT if maintenance is not properly carried out due to flooding in the rainy season. The environmental protection sector intends to extend UDDT near lakes to prevent the discharge of human excreta into water bodies.

Improved private pit latrines have a basic health function and are well maintained due to a simple design, low cost and household stewardship. They can be extended to the rural areas with safe reuse of human excreta in small farming.

Biogas digesters can be scaled up in rural areas with a moderate temperature all year round and sufficient animal excreta for enough digestion to produce gas, since a family of four members does not have sufficient human excreta to digest. Private septic tanks currently under extension in lakeside rural areas are a feasible option, but not financially viable due to their high capital and financial investment. A joint neighborhood septic tank is more economic, but the maintenance is problematic due to a lack of institutional teams in rural areas to manage them.

Scaling up sanitation programs in rural villages with different ethnicities has to consider the physical conditions and cultural preference for sanitation options in rural areas. The Yi ethnic group living upland and the Zhuang ethnic group living by lakes or rivers will have markedly different sanitation options.

The peri-urban areas are under transformation from rural to urban, and some peri-urban areas have been included in urban planning to be demolished for total reconstruction. Governmental sanitation programs have to consider this factor to avoid wastage of funds. The choices of sanitation option of peri-urban residents are very different from rural residents. Flush toilets with septic tank are mostly preferred by peri-urban residents. Since peri-urban areas are between

**TABLE 44:** CHARACTERISTICS OF FIELD SITES SELECTED IN THE ESI STUDY

| Sites | Average family size | Climate | Social group | Population of site | Economy (average income per capita) | Sanitation coverage (2008) |
|---|---|---|---|---|---|---|
| Typical locations | | | | | | |
| 1. Provincial capital (Kunming, U1) | 3 family members | Low altitude uplands monsoon climate with water scarcity | Han dominated | 3.2 million urban residents, 6.08 million including rural residents | 16,495 yuan | 87% of urban area (60% including rural area) |
| 2. Prefectural capital (Dali, U2) | 4 | Mountainous monsoon climate | Bai | 610,000 urban residents | 14,100 RMB yuan per capita | 67% |
| 3. County capital (Qiubei, U3) | 4 | Mountainous monsoon climate with flooding in rainy season | Yi, Miao | Less than 100,000 | < 3,500 yuan per capita | 50% |
| 4. Small town (Pu1, Jinning, PU1) | 3 | Lakeside, monsoon climate | Han | Less than 50,000 residents | 9,000 yuan per capita | 67% |
| 5. Urbanizing rural (Dali Zhoucheng, PU2) | 4 | Lakeside | Bai | Around 10,000 residents | 5,135 yuan per capita | 45% |
| 6. Northern lakeside plain rural (Dali Shangguan, R2) | 4 | | Bai | Around 10,000 residents | 3,480 yuan per capita | 45% |
| 7. Mountainous rural, watershed protected area (Kunming, Luquan, R1) | 5 | Cool mountainous | Yi | 200-500 villagers per village | 1,632 yuan per capita | 30% |
| 8. Southern lakeside and mountainous rural (Qiubei, R3) | 4 | Flooding | Zhuang | 200-500 villagers per village | < 1,500 yuan per capita | 46% |

city and rural, some are to be urbanized and other small towns have more rural characteristics. It is important to have a suitable sanitation program for specific sites.

Urban areas have been under strategic planning of the cities, and household flush toilets are widely used. Public flush toilets should be well planned and constructed in communities and crowded areas. While improving centralized wastewater treatment plants and the sewerage system, decentralized community-based wastewater treatment plants should be further promoted and enforced to reuse water resources to mitigate the water scarcity problem. The county-level cities like Qiubei city have been targeted to construct sewerage systems and wastewater treatment plants by governmental programs. It is urgent to scale up sanitation and hygiene programs in the county-level cities with rapid urbanization and population expansion. Flush-toilets with sewerage and wastewater treatment plants are a model to be extended to county-level cities with an increase in financial investment from the central government.

## 7.4 OVERALL COST-BENEFIT ASSESSMENT

This study has shown that the economic performances of sanitation options and hygiene in all the sites of Yunnan are favorable in comparison with "no toilet." All the sanitation options in rural areas have very high efficiency. In comparison with "no toilet," the benefit-cost ratios of all sanitation options are above 4, meaning the economic benefits of improving sanitation and hygiene are at least four times the cost. Under ideal conditions they range from almost eight for septic tanks to over 14 for UDDT. The most efficient option is UDDT, followed by pit latrine and biogas. Cost-effective measures range from US$271.6 per DALY averted for UDDT to US$478.8 per DALY averted for septic tank. However, as documented, there is a significant loss of efficiency from ideal to actual ratios.

The sanitation options in peri-urban areas have very different economic performances from rural areas. UDDT and private latrines have a higher efficiency of 5.3 and 5.0 respectively. Septic tanks have an actual BCR of 2.7, which is the minimum among the four sanitation options after shared toilets of 3.9. Very few biogas units were extended in peri-urban areas because few peri-urban households have domestic animal husbandry for providing the raw materials. Cost-effectiveness measures for the same sanitation option are higher than those in rural areas, ranging from US$461 per DALY averted for UDDT to US$861 per DALY averted for septic tanks.

The economic performance of sanitation options in urban areas in comparison with "no toilet" is lower than those of rural areas due to higher annual investment costs in comparison with the benefits obtained. Benefit-cost ratios range from 2.5 for sewerage to 4 for septic tanks to between 6 and 7 for shared and public toilets, to 8 or over for pit latrines and UDDT. As in rural areas, there is a significant loss of efficiency from ideal to actual ratios in urban areas. Cost-effectiveness measures range from US$305 per DALY averted for public toilets to US$ 886 per DALY averted for septic tanks, to US$1,385 per DALY averted for sewerage.

In rural areas, the efficiency of improved sanitation moving to higher cost options from shared to private pit latrines to UDDT to biogas are 2.9, 0.7 and 1.7 respectively. The efficiency of the UDDT alternative to shared is less than 1.0 and the NPV is negative. The health cost-effectiveness of the UDDT alternative to shared is significant with a cost per DALY averted of US$632. The incremental efficiency of improved pit latrines is significant in comparison with shared toilets. Other sanitation options are not very different from pit latrines, so the incremental BCR of moving from pit latrines is not favorable, with a benefit-cost ratio of less than one. But cost effectiveness measures range from US$448 per DALY averted for moving from shared to biogas, to US$1,084 per DALY averted for moving from pit latrine to septic tank.

In urban areas, the economic performance of moving from septic tank to sewerage is not favorable, but the health impact of sewerage is significant. Cost-effectiveness measures for moving from septic tank to sewerage is US$1,408 per DALY averted.

# VIII. Discussion

## 8.1 STUDY MESSAGES AND INTERPRETATION

### 8.1.1 MAIN MESSAGES

This study has shown that the economic performance of sanitation options and hygiene in all sites of Yunnan is highly favorable in comparison with not having basic sanitation. In rural areas, all the sanitation options are highly efficient, with UDDT, private pit latrines, 3-in-1 biogas units, shared toilets and private septic tanks having a benefit-cost ratio ranging from 4.7 to 9.4 under actual program conditions. If all program beneficiaries had used their new latrines appropriately, economic returns would have varied between 7.6 and 14.9. The sanitation options in peri-urban areas have slightly lower economic performances than rural areas, but still highly favorable. In urban sites, the most common sanitation options of public toilets, septic tanks and sewerage have benefit-cost ratios of 1.9 to 4.5 under actual program conditions. The benefits analyzed include benefits from health, water, access time, intangibles, the external environment and waste reuse. The economic value of health benefits is the largest contributor to overall quantified benefits.

However, there are benefits that are important but not monetized or included in the calculation. For instance, the FGD revealed that about 40% of women and men considered privacy and convenience to be the main reason/advantage to have a private toilet. These and other benefits are hard-to-quantify "intangible" benefits related to the toilet itself (e.g. comfort, prestige, privacy status and safety) as well as the "external" environment benefit (e.g. cleaner surroundings and less exposure to insects and rodents). Economic savings from improved water resource access and reduced household water treatment attributed to water pollution were not fully quantified in this study, but can be significant to downstream water resources in particular.

The incremental efficiency of improved pit latrines and biogas in rural areas is significant in comparison with shared toilets, due to additional time savings and value of excreta reuse. Moving higher up the ladder from pit latrines – for example – to UDDT, biogas and septic tanks brings only limited additional economic gain. Therefore, the incremental BCR of upgrading from a pit latrine to these options is not worthwhile from the perspective of quantified benefits. However, if the pit latrine has come to the end of its useful life and needs to be replaced or significantly renovated, then from an economic perspective it is more worthwhile to consider moving higher up the ladder or to more costly options. In urban areas, the economic performance of moving from septic tanks to sewerage is not economically justified. However, households may wish to improve their sanitation option for several reasons not quantified in the cost-benefit analysis such as intangible factors and the external environment.

The study provides strong arguments to support that improved sanitation and hygiene have a significant health economic impact. It informs decision makers that health benefits contribute the most, especially in rural populations and for children, who have relatively more to gain from improved sanitation. In general, it is estimated that it costs an average household around 1,000 RMB for disease treatment per year. In severe cases, it can cost several thousand, up to 10,000 RMB yuan for inpatient treatment with additional 500 RMB income losses from time off productive activities. The 0-4 year old age group – those most vulnerable to the negative health impacts of poor sanitation – has the highest health care cost, productivity cost (from carer time), and premature mortality cost.

The program approach analysis analyzed the effectiveness of existing sanitation options from two important aspects: the project implementation approach (associated with the construction phase) and the post-construction management (use and maintenance). It is somewhat concerning that less than 30% of the households stated that they had a choice whether to participate in the project or not, and less than 25% of households were provided with a choice of options when constructing their facilities, thus indicating that government programs are heavily "top-down". The feedback on satisfaction levels of households towards sanitation options and the external environment was around 3.0 – 3.5 on average (1 = not satisfied and 5 = very satisfied), and waste reuse rate was 71%, suggesting some economic value is not being captured by households or communities, and having significant room for improvement. It also indicates that even for households already equipped with improved sanitation facilities, many of them are not capturing the full health and environmental benefits. Sanitation and hygiene awareness, operation and maintenance training are required to reach full effectiveness of these facilities.

People perceive comfort (83%) proximity (82%), privacy (77%) and cleanliness (70%) to be the most important reasons for having a private toilet. Rural households without their own toilets expect to have private improved pit latrines or use public toilets in the community. Most villagers think having an improved private pit latrine is more applicable as it can collect manure and is easy to clean, with a 3-in-1 biogas unit taking second place. UDDT is not accepted widely by most households and is ranked in third place because of the poor quality of sanitation facilities provided and this technology requires a change of habits in using and maintaining it. Urban households with flush toilets have a high level of satisfaction, and those without flush toilets wish to have their own flush toilet in the future. Peri-urban households using public toilets prefer flush toilets connected to septic tanks or sewerage.

Moving up the ladder can involve a cost saving when hardware is reused, and thus it is more relevant to measure incremental rather than full cost of the higher ladder sanitation options. When full cost is applied, the hardware is replaced. Moving up the ladder from pit latrines to biogas units and from septic tanks to sewerage involves a partial cost saving: US$200 for the former and US$770 for the latter. All the other sanitation options of moving up to the targeted options need full cost because of the investment in the full hardware costs. Septic tanks and sewerage at the top of the sanitation option cost ladder have a total economic cost of US$1,400 and US$2,170 per household, respectively. Moving up the sanitation ladder is to be expected in the longer run as populations' disposable income grows, but shifting from one option to another option at the same level should be avoided. It is important to consider the cost and technology suitability from a long-term perspective when making investment decisions.

Sanitation infrastructures in China are largely subsidized by the government: 54-68% of capital investment and about 30% of overall sanitation costs when recurrent cost is included for sites of the ESI study. The FGD hinted that at all sites, when reasons were asked for why households did not have a private latrine, both men and women responded that "no external support" was the main reason. This reason was given more often than the response that the cost of a latrine is too high. It explains the reluctance of potential users in contributing their own funds, indicating a heavy dependence on government investment. To fill the gap between available financial resources and the actual budget required for achieving full access and increase users' ownership towards sanitation facilities, sanitation beneficiaries' demand needs to be stimulated, for which innovative approaches are required.

### 8.1.2 GENERALIZABILITY OF RESULTS

Yunnan is the eighth largest province in terms of area in China and its geographical, cultural, ecological, climatic, social and economical development differ very much from place to place, which implies that sanitation in Yunnan will be very location-specific. Therefore the ESI study attempted to select field sites which reflected different contexts within the province, hence enabling broader lessons to be drawn from the site-specific studies. Given the available research resources, eight sites covering three regions were identified. The sites were based on various considerations such as economic development, rural/urban/peri-urban, population size, sanitation options, ethnicity of local residents, altitude, and proximity to important water resources. Extreme geographical locations, such as alpine, tropical and border areas, were not selected.

The three urban sites – Kunming, Dali and Qiubei – represent provincial, prefectural and county level cities, respectively. It is likely that other cities of the same level will have similar costs and benefits from improved or unimproved sanitation and incremental cost for climbing up the ladder. Kunming is large in population and area size. Under Kunming's administration, Anning city, considering its size and development, is comparable to Dali city (urban, peri-urban and rural), Songming (peri-urban), Qiubei (rural) and Luquan (rural). Its counties, except for Songming, are more or less identical to Songming (peri-urban), Qiubei (urban/small size city and rural), Luquan (rural) and Dali (peri-urban and rural).

Areas with low improved sanitation coverage, with typical characteristics such as open defecation practices and unprotected ground water sources, will have similar health status and water variables. Likewise, areas with similar demographic situations such as population density, age composition of family members and average wage, will have similar benefits once their sanitation facilities are improved.

## 8.2 POTENTIAL USES OF RESULTS

There are several opportunities that the study results can be used for:

**Advocacy for sanitation improvement:** costs and benefits of improved sanitation can be convincing points for requesting stronger support from the governmental budget, donors and other organizations. They can be used by program staff to convince households actively participating in sanitation improvement programs to contribute to the hardware construction. The general media, health sector, environmental sector and public societies can use these messages in their advocacy campaigns for raising public awareness towards the importance of improved sanitation.

**Selection of sanitation options:** different sanitation options, which are perceived differently by households and sanitation practitioners and promoting organizations, have different financial and economic implications. The features of each sanitation option, not only technical, but also social acceptance, financial and economical costs, are important and determine the success of an installation. The study results help understand the household perceptions, and on the other hand, the right messages about the technical and financial strengths and weaknesses of sanitation technologies can be passed on to households as well. Improved communication between suppliers and beneficiaries ensures that the most appropriate technology is adopted and fully accepted by the users. Particularly when a budget is limited, it is helpful to compare the BCRs, NPVs, and incremental costs of different options, to prioritize investment and decide the level of sanitation technology.

**Program design and implementation:** The Chinese government's annual investments on sanitation are significant, and requests for rapid scale-up often mean a large number of sanitation infrastructures are to be built within a short period. Either insufficient attention or inadequate financial and human resources prevent thorough planning, awareness raising, training, beneficiary consultation, supervision and post-evaluation that are essential for effective sanitation improvement initiatives. The messages coming across from PAA also emphasize the importance of shifting from a supply-driven approach to a demand-driven approach.

**Sanitation investment:** cost-benefit analysis results provide indicative figures for each technical option, costs for moving up the sanitation ladder and periods over which there are returns on the investment. This is helpful for calculating the overall cost for achieving certain sanitation access rates and comparing the general effectiveness of technologies at a similar level.

**Research study:** The ESI study methodology and approach itself can serve as a starting point for carrying out further sanitation-related research, for instance, on how to quantify environmental impacts of unimproved sanitation, how to monetize the intangible benefits of improved sanitation, and the comparative costs of scaling up different types of sanitation options.

## 8.3 INTEGRATING ECONOMIC CONSIDERATIONS INTO A DECISION MAKING PROCESS

Currently in Yunnan or even China, sanitation planning largely relies on qualitative arguments. Limited economic aspects are considered, except for large sanitation infrastructure (sewage system and treatment plants, centralized human waste disposal sites) and in the context of development loans from external agencies and banks. Economic evidence from this study can now be used to strengthen the feasibility and planning phases of future sanitation projects. However, it might require more solid and robust studies to be carried out in the specific context of the projects to justify the decisions made. Similar studies need to be conducted in other provinces of China.

# IX. Recommendations

The aim of this study is to provide the evidence and the arguments for national and provincial decision makers to make more efficient investments in sanitation. This study has quantified the economic efficiency of selected sanitation options. It supports several agendas, leading to both improved sanitation at the household level as well as improved environmental protection contributing to watershed protection, thus resulting in benefits to public health, the natural environment, economic development, and poverty alleviation. The following policy recommendations are based on the major findings of the study.

**Recommendation 1. Populations without access to basic sanitation should be prioritized by sanitation and hygiene programs and be the first to receive subsidies.**

The findings of the research show that the investment on improving access to basic sanitation targeted to those without basic sanitation generates the highest efficiency. Efficiency is significantly lower for those who already have basic sanitation but are moved up the sanitation ladder by sanitation programs. Therefore, those without basic sanitation or improved sanitation in remote mountainous areas and peri-urban areas should be targeted by governmental projects. The central and local governments should increase the investment in sanitation and hygiene development for those without sanitation in the western region of China. Preferential policies should be given to low-income populations without improved sanitation in Yunnan. These policies need to be included in the socio-economic development plan and sectoral plans of the province.

**Recommendation 2. The importance of hygiene and health aspects should be better reflected in sanitation programs.**

Improved sanitation with waste management and hygiene has a high degree of impact in averting the disease burden and hence reducing health care costs, productivity losses and welfare losses due to premature mortality. Investment in sanitation and hygiene is an important method of disease control, which reduces household, government and private sector expenses associated with disease. Sanitation and hygiene interventions should be planned and implemented jointly in order to promote the health of the people. Sanitation should include toilets and the facilities for solid waste treatment, wastewater treatment and hand washing. Comprehensive sanitation programs should be promoted in order to avoid piece-meal projects with little connection to one another. Integrating hygiene awareness and improving hygiene practices in sanitation programs are crucial to capturing the important health benefits. Awareness campaigns on hand washing should be strengthened since hand washing is a low cost method of reducing transmission of infectious diseases.

**Recommendation 3. Go beyond basic sanitation provisions.**

In many municipalities and counties of Yunnan Province, funds are adequate to deliver more sustained and quality services, which better capture the full environmental and health benefits of better sanitation, and respond to the population's wish for a clean, livable environment.

**Recommendation 4. Innovative funding strategies are required to encourage multiple sources of contribution.**

Governmental funds for sanitation and hygiene are far from adequate for achieving full basic sanitation. For Yunnan, a province with nearly 6.4% of its population under the nationally-defined poverty line (less than US$0.5 per day), this is even more challenging. To respond to the investment deficit, flexible and diversified co-financing mechanisms need to be applied, particularly mechanisms to attract private sector investment and approaches to raise beneficiary demand. In this respect, international experiences can be drawn upon and adapted to conditions in China, such as Community-led Total Sanitation (CLTS), which has had widespread success in South and Southeast Asia as well as Eastern Africa. Program costs on education, training, water supply, and evaluation components of sanitation-related programs, as well as liquids and solids management and hand washing, have to be secured to maximize the benefits of sanitation infrastructure.

**Recommendation 5. Closer and stronger inter-sectoral coordination and cooperation are required for effective and sustainable sanitation improvement.**

Although cross sectoral coordination and cooperation are taking place in Yunnan, government programs are still largely vertical. The many agencies involved in sanitation provision suggest that efficiency gains could be made from improved cross-sectoral coordination and cooperation, which will lead to improved planning and choice of technologies, strengthened mutual learning and resource saving. With continued rapid urbanization and rural development in Yunnan Province, the line between rural and urban solutions will become less clear; therefore, stronger cooperation between the existing separate coordination systems for urban and rural areas is needed–or even an overall coordinating mechanism covering both rural and urban areas.

Successful sectoral coordination and cooperation implies improved planning, optimizing investment effectiveness, strengthened mutual learning and communication and resource saving. For this purpose the study suggests to establish an inter-departmental cooperation mechanism for both urban and rural sanitation. As inter-departmental cooperation requires a strong governmental body to lead all activities, this report recommends that the Provincial Government or the Provincial Development and Reform Commission act as an overall coordinating body to integrate sectoral resources and invest in sanitation. The technical guidance and coordination role should remain as it currently is: the Housing and Urban-Rural Development Department is responsible for urban areas and the Health Department is in charge of rural areas.

**Recommendation 6. People-centered implementation approaches are advised to improve participation and consultation of beneficiaries.**

As the program approach analysis indicated, the supply-led approach has some advantages but also several weaknesses such as low willingness to participate, lack of ownership, low acceptance of the technology or infrastructure, among other problems. The traditional supply-driven program approach adopted by the majority of projects should shift away from business-as-usual to a more demand-oriented approach. In order to understand the demand of the targeted users, implementing agencies should adopt novel approaches to interact with local people by building dialog and communication. It is necessary to involve the users, especially women, in the full project life cycle, from planning, decision making, design, construction, maintenance, and monitoring and evaluation of the sanitation facilities.

**Recommendation 7. Women should be motivated and empowered in decision making, implementation as well as monitoring; the demonstrative and educational function of schools should be exploited.**

The study findings demonstrate that women's needs are somewhat different from men's needs when it comes to sanitation. Women demand safer, more private, cleaner sanitary latrines. In fact, women are responsible for most household tasks, including house and toilet cleaning and hygiene, family members' health, especially young children. Therefore women's central role in family sanitation should be more fully appreciated and taken into account in decision making at the community level. It is crucial for children to develop hygiene and sanitation awareness from the very beginning, and children's influence in the family can also be prominent and is worth promoting. For the above reasons, hygiene and sanitation knowledge should be provided to women and students in various ways.

**Recommendation 8. Setting up comprehensive databases is crucial for information sharing.**

As indicated in Chapter 1, the sanitation system in China is highly complex, due to the multiple and multi-sector stakeholders involved, different program orientations, variety of funding sources and mechanisms, and the very distinct sanitation situations by region and localities. During the program approach analysis, the team identified several weaknesses in the current data system caused by the system's complexity. First, different data sources present very different figures for the coverage of sanitary latrines in rural areas. Second, in the past, systematic surveys of sanitary latrine coverage focused on rural areas, resulting in a lack of data on sanitation coverage in urban areas. This, in turn, translates into a lack of combined urban and rural statistical data. Third, program cost is often missing in governmental budget plans as governmental programs mainly focus on physical infrastructure. Therefore the actual cost is underestimated and the budgeting requirement for software cost in programs is not appreciated by either decision makers or implementers.

As the primary goal of all hygiene and sanitation projects is to improve public health and social well-being, all sector projects should share an overall set of health, environmental, socio-economic and technical indicators, in addition to project-specific indicators. These indicators should capture the multiple benefits of environmental health and sanitation facilities, including health gains, renewable energy development, avoided water pollution, quality of life improvement (especially for women), and the opportunity cost of time (productive uses). Future efforts should build on the databases and experiences from the ESI study.

This report recommends that the Patriotic Health Campaign Committee (PHCC) coordinate with other departments and come to an agreement on a revised database to address the abovementioned problems. Regular exchanges and information sharing among relevant sectoral departments should be institutionalized for better coordination. PHCC should make data and information available to the public as well, for instance, via information bulletins uploaded to their website.

**Recommendation 9. Conduct further sanitation-related research.**

Based on the results presented in this study, more specific studies would help in verifying, supporting or extending the messages, especially the economic valuation of the benefits of improved sanitation. The following topics are suggested for follow-up in the near future: 1) valuation of environmental impacts of unimproved sanitation; 2) valuation of intangible benefits of improved sanitation; 3) program costs of governmental and non-governmental sanitation programs; and 4) market-based private sector involvement and demand oriented approaches.

**Recommendation 10. Promote evidence-based sanitation decision making.**

Variations in economic performance of options suggest a careful consideration of site conditions is needed to select the most appropriate sanitation option and delivery approach. Decisions should take into account not only the measurable economic costs and benefits, but also other key factors for a decision, including intangible impacts and socio-cultural issues that influence demand and behavior change, availability of suppliers and private financing, and actual household willingness and ability to pay for services.

# ANNEX A: STUDY METHODS

**TABLE A1:** SELECTION OF FIELD SITES FOR ECONOMIC STUDY

| Program name | Location(s) covered | Implementing agents | Funding mechanism | |
|---|---|---|---|---|
| SELECTED PROGRAMS | | | | REASON FOR INCLUSION |
| Biogas program by Qiubei County Forestry Bureau | Daleshao Village, Qiubei County | Energy Station, Forestry Bureau Qiubei County | 66.7% covered by government, 33.3% covered by the household | The data can be obtained, and can be compared with the same type of sanitation. |
| Puzhehei Upstream Eco-sanitation Project Phase I & II | Puzhehei Lake watershed, Qiubei County, Wenshan Prefecture, Yunnan Province, China | Yunnan Environment Development Institute | The project covered 80% of the construction costs, voluntarily participating households covered the remaining 20%. | |
| Luoguo village Ameng Township Yanshan County Biogas program | Luoguo village Ameng Township Yanshan County | Yunnan Green Environment Development Foundation | Project covered all the expenses | |
| Lanping County City Wastewater Treatment program | Jinding Township Lanping County | Urban and Rural Construction Bureau Lanping County | 70% of capital from treasury bonds, 20% from loan,10% matching funds by local government | |
| NON-SELECTED PROGRAMS | | | | REASON FOR EXCLUSION |
| Jinning UDDT program by Kunming City Environment Protection Bureau | Zhonghe Village, Jinning Kunming | Kunming City Environment Protection Bureau | | The data is not sufficient for analysis, and the wastewater treatment plant of Yunlong has not been in operation. |
| The WWT program in Luquan | Yunlong Reservoir Area | Kunming Dianchi Investment Company, Kunming Municipal Land Resource Committee | | |

**TABLE A2:** ASSESSMENT OF ADVANTAGES AND LIMITATIONS OF DIFFERENT DESIGN OPTIONS

| No | Design | Advantages | Limitations |
|---|---|---|---|
| DESIGNS INVOLVING FIELD DATA COLLECTION | | | |
| 1 | Economic study designed entirely for research purposes, including matching and randomization of comparison groups | • Addresses the specific questions of the research<br>• Highly scientific design | • Expensive and lengthy period<br>• May not capture health impact<br>• Limited generalisability |
| 2 | Economic research attached to other research studies (e.g. randomized clinical trials) | • Captures health impact with degree of precision<br>• Can conduct additional research on other impacts<br>• Add-on research cost is small<br>• Statistical analysis possible | • Expensive and lengthy period<br>• Few ongoing clinic trials<br>• Requires collaboration from start<br>• Trials may not reflect real conditions<br>• Limited comparison options |
| 3 | Economic research attached to pilot study, with or without randomization | • Add-on research cost is small<br>• Options are policy relevant<br>• Matched case-control possible<br>• Can start research in mid-pilot | • Few pilot programs available<br>• Pilots often not designed with scientific evaluation in mind (e.g. before vs. after surveys)<br>• Pilot conditions not real life<br>• Limited comparison options |
| 4 | Economic research attached to routine government or NGO/donor programs, without randomization | • Reflects real life conditions (e.g. uptake and practices)<br>• Research addresses key policy questions<br>• Matched case-control possible | • No research infrastructure<br>• No scientific design<br>• Limited comparison options |
| DESIGNS INVOLVING SECONDARY DATA COLLECTION | | | |
| 5 | Collection of data from a variety of local sources to conduct a modeling study | • Relatively low cost<br>• Short time frame feasible<br>• Can compare several options and settings in research model<br>• Can mix locally available and non-local data | • Results imprecise and uncertain<br>• Actual real-life implementation issues not addressed |
| 6 | Extraction of results from previous economic studies | • Low cost<br>• Results available rapidly<br>• Gives overview from various interventions and settings | • Limited relevance and results not trusted by policy makers<br>• Published results themselves may not be precise |

**TABLE A3.** METHODOLOGY FOR BENEFIT ESTIMATION (CALCULATIONS, DATA SOURCES, EXPLANATIONS)

| Impacts included | Variable | Data sources | Specific value/comment |
|---|---|---|---|
| **1. HEALTH** *(All calculations are made using disaggregated data inputs on disease and age grouping: 0-4 years, 5-14 years, 15+ years)* | | | |
| **1.1 Health care savings** *Calculation: [Prevalence or incidence X Attribution to poor sanitation X ((% seeking outpatient care X visits per case X unit cost per visit (medical and patient)) + (Inpatient admission rate X days per case X unit cost per day (medical and patient))] X Proportion of disease cases averted* | Diarrheal disease incidence (0-4 years) | | |
| | Diarrheal disease incidence (over 5 years) | WHO statistics | |
| | Helminthes prevalence | Global review | |
| | Hepatitis A and E incidence | National health statistics | |
| | Indirect diseases incidence (malaria, ALRI) | WHO statistics | |
| | Malnutrition prevalence | UNICEF/WHO statistics | |
| | Scabies and trachoma Incidence | National health statistics | |
| | Attribution of fecal-oral diseases to poor sanitation | WHO (Prüss et al. 2002) | Value = 88% |
| | Attribution of helminthes to poor sanitation | Global review | Value = 100% |
| | % disease cases seeking health care | ESI household survey, health statistics | |
| | Outpatient visits per patient | Health facility statistics, ESI household survey | |
| | Inpatient admission rate | | |
| | Inpatient days per admission | | |
| | Health service unit costs | | |
| | Other patient costs (transport, food) | ESI household survey | |
| | % disease cases averted | International literature review | See Annex B for review |
| **1.2 Health morbidity-related productivity gains** *Calculation: [Prevalence X Attribution to poor sanitation X Days off productive activities X Value of time] X Proportion of disease cases averted* | Days off productive activities | ESI household survey | |
| | Basis of time value: GDP per capita | National economic data | Average product per capita (at sub-national level, where available) – 30% for adults, 15% for children |
| **1.3 Premature mortality savings** *Calculation: [Mortality rate X Attribution to poor sanitation X Value of life] X Proportion of disease cases averted* | Mortality rate (all diseases) | WHO statistics | (cross-checked with local stats) |
| | Basis of time value: GDP per capita | National economic data | Annual value of lost production of working adults(human capital approach) , from the time of death until the end of (what would have been) their productive life |
| | Discount rate for future earnings | National government | Cost of capital estimate (8%) |
| | Long-term economic growth | Assumption | |
| | Value-of-statistical-life | Developed country studies | Adjusted to local purchasing power by multiplying by GDP per capita differential |

**TABLE A3.** METHODOLOGY FOR BENEFIT ESTIMATION (CALCULATIONS, DATA SOURCES, EXPLANATIONS) (CONTINUED)

| Impacts included | Variable | Data sources | Specific value/comment |
|---|---|---|---|
| **1.4 Disability-adjusted life-years (DALY) averted**<br><br>*Calculation:*<br>*DALY = YLD+YLL*<br>*YLD: discounted disability based on weight and years equivalent time*<br>*YLL: discounted future years of healthy life lost* | Duration of disability | ESI household survey | based on average length of each disease |
| | Disability weighting | WHO burden of disease project | |
| | Healthy life expectancy | WHO statistics | |
| | Discount rate for future disease burdens | National governments | Cost of capital estimate (8%) |
| | Morbidity and mortality rates | Various: see 1.1 and 1.3 (above) | |
| **2. WATER (for household use)**<br>*(weighted average costs were estimated for each water source and for each household water treatment method)* | | | |
| **2.1 Household water access savings**<br><br>*Calculation:*<br>*Annual costs X % costs reduced, per water source* | Drinking water sources (%) in wet and dry seasons | ESI household survey | |
| | Annual financial cost per household, per water source | ESI household survey; ESI market survey | |
| | Annual non-financial cost per household, per water source | ESI household survey | |
| | Proportion of access cost reduction under scenario of 100% improved sanitation, per water source | ESI household survey; assumption | |
| **2.2 Household water treatment savings**<br><br>*Calculation:*<br>*(% households treating water per method X annual cost) X % households who stop treating* | Proportion of households treating their water, by method | ESI household survey | Validated by other national statistics (DHS, SES) |
| | Full annual cost per water treatment method | ESI household survey; ESI market survey | |
| | Proportion of households currently treating who stop treating under scenario of 100% improved sanitation | ESI household survey; assumption | As well as stopping to treat water, households may switch to an alternative – cheaper – treatment method if the cleaner water sources enable different water purification methods |
| **3. ACCESS TIME SAVINGS**<br>*(weighted average costs estimated for each age category and gender – young children, children and male and female adults)* | | | |
| *Calculation:*<br>*% household members using OD X Time saved per trip due to private toilet X average trips per day X value of time* | Household composition (demographics) | ESI household survey | |
| | Sanitation practice, by age group | ESI household survey | |
| | Average round trip time to access site of open defecation | ESI household survey | For households moving from shared to private toilet, access time to shared toilets is used instead of OD |
| | Average number of round trips to defecation site per day | ESI household survey | |
| | Basis of time value: GDP per capita | National economic data | Average product per capita (at sub-national level, where available) – 30% for adults, 15% for children |

**TABLE A3.** METHODOLOGY FOR BENEFIT ESTIMATION (CALCULATIONS, DATA SOURCES, EXPLANATIONS) (CONTINUED)

| Impacts included | Variable | Data sources | Specific value/comment |
|---|---|---|---|
| **4. EXCRETA REUSE GAINS** *(reuse of excreta as fertilizer from either UDDT or double-vault pit latrine; and reuse of energy value from biogas digester)* | | | |
| *Calculation: (% households using product themselves X value in own use) + (% households selling product X selling price)* | % households using reuse methods | ESI household survey | |
| | % households using product themselves | ESI household survey | |
| | % households selling product to others | ESI household survey | |
| | Selling price | ESI household & market survey | |
| | Value in own use | ESI market survey; assumption | |

**TABLE A4:** DISEASES LINKED TO POOR SANITATION AND HYGIENE, AND PRIMARY TRANSMISSION ROUTES AND VEHICLES

| Disease | Pathogen | Primary transmission route | Vehicle |
|---|---|---|---|
| DIARRHEAL DISEASES (GASTROINTESTINAL TRACT INFECTIONS) | | | |
| Rotavirus diarrhea | Virus | Fecal-oral | Water, person-to-person |
| Typhoid/paratyphoid | Bacterium | Fecal-oral and urine-oral | Food, water + person-person |
| Vibrio cholera | Bacterium | Fecal-oral | Water, food |
| Escherichia Coli | Bacterium | Fecal-oral | Food, water + person-person |
| Amebiasis (amebic dysentery) | Protozoa [1] | Fecal-oral | Person-person, food, water, animal feces |
| Giardiasis | Protozoa [1] | Fecal-oral | Person-person, water (animals) |
| Salmonellosis | Bacterium | Fecal-oral | Food |
| Shigellosis | Bacterium | Fecal-oral | Person-person + food, water |
| Campylobacter Enteritis | Bacterium | Fecal-oral | Food, animal feces |
| Helicobacter pylori | Bacterium | Fecal-oral | Person-person + food, water |
| Protozoa | | | |
| Other viruses [2] | Virus | Fecal-oral | Person-person, food, water |
| Malnutrition | Caused by diarrheal disease and helminthes | | |
| HELMINTHES (WORMS) | | | |
| Intestinal nematodes [3] | Roundworm | Fecal-oral | Person-person + soil, raw fish |
| Digenetic trematodes (e.g. Schistosomiasis Japonicum) | Flukes (parasite) | Fecal/urine-oral; fecal-skin | Water and soil (snails) |
| Cestodes | Tapeworm | Fecal-oral | Person-person + raw fish |
| Eye diseases | | | |
| Trachoma | Bacterium | Fecal-eye | Person-person, via flies, fomites, coughing |
| Adenoviruses (conjunctivitis) | Protozoa [1] | Fecal-eye | Person-person |
| Skin diseases | | | |
| Ringworm (Tinea) | Fungus (Ectoparasite) | Touch | Person-person |
| Scabies | Fungus (Ectoparasite) | Touch | Person-person, sharing bed and clothing |
| OTHER DISEASES | | | |
| Hepatitis A | Virus | Fecal-oral | Person-person, food (especially shellfish), water |
| Hepatitis E | Virus | Fecal-oral | Water |
| Poliomyelitis | Virus | Fecal-oral, oral-oral | Person-person |
| Leptospirosis | Bacterium | Animal urine-oral | Water and soil - swamps, rice fields, mud |

Sources: WHO http://www.who.int/water_sanitation_health/en/ and [75, 76]

[1] There are several other protozoa-based causes of GIT, including
- Balantidium coli – dysentery, intestinal ulcers
- Cryptosporidium parvum - gastrointestinal infections
- Cyclospora cayetanensis - gastrointestinal infections
- Dientamoeba fragilis – mild diarrhea
- Isospora belli/hominus – intestinal parasites, gastrointestinal infections

[2] Other viruses include:
- Adenovirus – respiratory and gastrointestinal infections
- Astrovirus – gastrointestinal infections
- Calicivirus – gastrointestinal infections
- Norwalk viruses – gastrointestinal infections
- Reovirus – respiratory and gastrointestinal infections

[3] Intestinal nematodes include:
- Ascariasis (roundworm - soil)
- Trichuriasis trichiura (whipworm)
- Ancylostoma duodenale/Necator americanus (hookworm)

**TABLE A5:** WATER QUALITY MEASUREMENT PARAMETERS PER LOCATION, AND TEST METHOD

| Parameter | Test | Location | Test conducted for | | |
|---|---|---|---|---|---|
| | | | Surface water | Well water | Piped tap water |
| E.coli (cfu/100 ml) | Multitube fermentation | Laboratory | Yes | Yes | Yes |
| Biological Oxygen Demand (BOD5) (mg/L) | 5 day incubation | Laboratory | Yes | | |
| Chemical Oxygen Demand (COD) (mg/L) | 5 day incubation | Laboratory | Yes | | |
| Dissolved Oxygen (DO) (mg/L) | Iodometric Method | Field | Yes | | |
| Ammonia (NH3-N) | Spectrophotometer | Laboratory | Yes | Yes | Yes |
| Nitrate (NO3-) (mg/L) | DX-120 HPIC | Laboratory | Yes | | |
| Nitrite (NO2-) (mg/L) | DX-120 HPIC | Laboratory | Yes | | |
| Total Phosphorous (TP) (mg/L) | Spectrophotometer | Laboratory | Yes | | |
| Total Nitrogen (TN) (mg/L) | Ultraviolet spectrophotometer | Laboratory | Yes | | |
| Conductivity (μS/cm) | DDS — 11A Conductivity meter | Field | Yes | Yes | Yes |
| Turbidity (NTU) | Turbidity meter | Field | Yes | Yes | Yes |
| pH | pH Probe | Field | Yes | | |
| Water temperature (oC) | Thermometer | Field | Yes | | |
| Residual chlorine (Cl) (in places provided with centralized chlorinated water supply) (mg/L) | Field Kit | Field | | | Yes |

**TABLE A6:** HOUSEHOLDS SAMPLED VERSUS TOTAL HOUSEHOLDS PER VILLAGE/COMMUNITY

| Site | Sampling of households | Sewerage/STF | | Septic tank | Pit latrine | UDDT | Shared toilet | Biogas toilet | Public toilet | OD | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | With treatment | Without treatment | | | | | | | | |
| Site 1 Kunming Urban | Sample | 33 | | 85 | | | | | | 2 | 120 |
| | Total | 120 | | 120 | | | | | | 120 | 120 |
| | % sampled | 28 | | 71 | | | | | | 2 | 100 |
| Site 2 Dali Urban | Sample | | 11 | 21 | 13 | | | | 16 | | 61 |
| | Total | | 61 | 61 | 61 | | | | 61 | | 61 |
| | % sampled | % | 18 | 34 | 21 | | | | 26 | | 100 |
| Site 3 Qiubei Urban | Sample | | | 50 | 13 | 3 | 2 | | | 4 | 72 |
| | Total | | | 72 | 72 | 72 | 72 | | | 72 | 72 |
| | % sampled | | | 69 | 18 | 4 | 3 | | | 6 | 100 |
| Site 4 Kunming Peri-urban | Sample | | | 58 | 12 | 15 | 55 | | | 1 | 141 |
| | Total | | | 141 | 141 | 141 | 141 | | | 141 | 141 |
| | % sampled | | | 41 | 9 | 11 | 39 | | | 1 | 100 |
| Site 5 Dali peri-urban | Sample | | | 17 | 17 | 9 | 16 | | | 1 | 60 |
| | Total | | | 60 | 60 | 60 | 60 | | | 60 | 60 |
| | % sampled | | | 28 | 28 | 15 | 27 | | | 2 | 100 |
| Site 6 Kunming rural | Sample | | | 117 | 33 | | | | | 1 | 151 |
| | Total | | | 151 | 151 | | | | | 151 | 151 |
| | % sampled | | | 77 | 22 | | | | | 1 | 100 |
| Site 7 Dali rural | Sample | | | 52 | 49 | 9 | 7 | 13 | | 3 | 133 |
| | Total | | | 133 | 133 | 133 | 133 | 133 | | 133 | 133 |
| | % sampled | | | 39 | 37 | 7 | 5 | 10 | | 2 | 100 |
| Site 8 Qiubei rural | Sample | | | 45 | 36 | 5 | 7 | 30 | | 48 | 171 |
| | Total | | | 171 | 171 | 171 | 171 | 171 | | 171 | 171 |
| | % sampled | | | 26 | 21 | 3 | 4 | 18 | | 28 | 100 |
| **Total** | **Sample** | **33** | **11** | **445** | **173** | **41** | **87** | **43** | **16** | **60** | **909** |
| | **Total** | **909** | **909** | **909** | **909** | **909** | **909** | **909** | **909** | **909** | **909** |
| | | **4** | **1** | **49** | **19** | **5** | **10** | **5** | **2** | **7** | **100** |

**TABLE A7:** SAMPLE SIZES OF OTHER SURVEYS IN STUDY SITES

| Site | Group | Focus Group Discussion | | | Physical location surveys | Health facilities | |
|---|---|---|---|---|---|---|---|
| | | Women | Men | Other groups | | Hospital | Clinic |
| Site 1 | Unimproved | | | | 1 | 1 | 2 |
| | Improved | 10 | 10 | | | | |
| | Sub-total | 10 | 10 | | | | |
| Site 2 | Unimproved | 5 | 5 | | 1 | 1 | 2 |
| | Improved | 5 | 5 | | | | |
| | Sub-total | 10 | 10 | | | | |
| Site 3 | Unimproved | 5 | 5 | | 1 | 1 | 1 |
| | Improved | 5 | 5 | | | | |
| | Sub-total | 10 | 10 | | | | |
| Site 4 | Unimproved | 5 | 5 | | 2 | 1 | 2 |
| | Improved | 5 | 5 | | | | |
| | Sub-total | 10 | 10 | | | | |
| Site 5 | Unimproved | 5 | 5 | | 1 | 1 | 2 |
| | Improved | 5 | 5 | | | | |
| | Sub-total | 10 | 10 | | | | |
| Site 6 | Unimproved | 5 | 5 | | 3 | 1 | 2 |
| | Improved | 10 | 10 | | | | |
| | Sub-total | 15 | 15 | | | | |
| Site 7 | Unimproved | 5 | 5 | | 2 | 1 | 2 |
| | Improved | 10 | 10 | | | | |
| | Sub-total | 15 | 15 | | | | |
| Site 8 | Unimproved | 5 | 5 | | 3 | 1 | 2 |
| | Improved | 10 | 10 | | | | |
| | Sub-total | 15 | 15 | | | | |
| **Total** | **Unimproved** | **35** | **35** | | **14** | **8** | **16** |
| | **Improved** | **60** | **60** | | | | |
| | | **95** | **95** | | | | |

# ANNEX B: HEALTH IMPACT

**TABLE B1:** RATES PER POPULATION FOR CASES OF DISEASE

| | Average rural sites | Average urban sites | Average peri-urban sites | Site 1 Kunming urban | Site 2 Dali urban | Site 3 Qiubei urban | Site 4 Kunming rural | Site 5 Dali rural | Site 6 Qiubei rural | Site 7 Kunming peri-urban | Site 8 Dali peri-urban |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DIRECT DISEASES | | | | | | | | | | | |
| Mild diarrhea | 1.03 | 0.767 | 0.8 | 0.60 | 0.80 | 0.90 | 0.90 | 1.00 | 1.20 | 0.70 | 0.90 |
| Severe diarrhea | 0.2 | 0.13 | 0.15 | 0.10 | 0.10 | 0.20 | 0.10 | 0.10 | 0.40 | 0.10 | 0.20 |
| Helminthes | 0.387 | 0.373 | 0.36 | 0.36 | 0.36 | 0.40 | 0.40 | 0.36 | 0.40 | 0.36 | 0.36 |
| Hepatitis A, E | 0.001 | 0.001 | 0.001 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Scabies | 0.1 | 0.1 | 0.1 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Trachoma | 0.001 | 0.001 | 0.001 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INDIRECT DISEASES | | | | | | | | | | | |
| Malnutrition | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Malaria | 0.1 | 0.002 | 0.0005 | 0.00 | 0.01 | 0.00 | 0.10 | 0.10 | 0.10 | 0.00 | 0.00 |
| ALRI | 0.1 | 0.04 | 0.05 | 0.02 | 0.05 | 0.05 | 0.10 | 0.10 | 0.10 | 0.05 | 0.05 |
| **Total** | **1.932** | **1.4273** | **1.4725** | **1.1925** | **1.427** | **1.6625** | **1.712** | **1.772** | **2.312** | **1.3225** | **1.6225** |

**TABLE B2:** RATES PER 1,000 POPULATION FOR DEATHS

| | Average rural sites | Average urban sites | Average peri-urban sites | Site 1 Kunming urban | Site 2 Dali urban | Site 3 Qiubei urban | Site 4 Kunming rural | Site 5 Dali rural | Site 6 Qiubei rural | Site 7 Kunming peri-urban | Site 8 Dali peri-urban |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DIRECT DISEASES | | | | | | | | | | | |
| Mild diarrhea | 6.348E-06 | 6.348E-06 | 6.348E-06 | 0.00001 | 6.348E-06 | 0.00001 | 6.348E-06 | 6.348E-06 | 6.348E-06 | 6.348E-06 | 6.348E-06 |
| Severe diarrhea | 0.0002 | 0.0001333 | 0.00015 | 0.00010 | 0.0001 | 0.00020 | 0.0001 | 0.0001 | 0.0004 | 0.0001 | 0.0002 |
| Helminthes | 0.0003867 | 0.0003733 | 0.00036 | 0.00036 | 0.00036 | 0.00040 | 0.0004 | 0.00036 | 0.0004 | 0.00036 | 0.00036 |
| Hepatitis A, E | 0.000001 | 0.000001 | 0.000001 | 0.00000 | 0.000001 | 0.00000 | 0.000001 | 0.000001 | 0.000001 | 0.000001 | 0.000001 |
| Scabies | 0.0001 | 0.0001 | 0.0001 | 0.00010 | 0.0001 | 0.00010 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Trachoma | 0.000001 | 0.000001 | 0.000001 | 0.00000 | 0.000001 | 0.00000 | 0.000001 | 0.000001 | 0.000001 | 0.000001 | 0.000001 |
| INDIRECT DISEASES | | | | | | | | | | | |
| Malnutrition | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| Malaria | 0.0001 | 0.000002 | 0.0000005 | 0.00000 | 0.000005 | 0.00000 | 0.0001 | 0.0001 | 0.0001 | 0.0000005 | 0.0000005 |
| ALRI | 0.0001 | 3.333E-05 | 0.00005 | 0.00002 | 0.00005 | 0.00003 | 0.0001 | 0.0001 | 0.0001 | 0.00005 | 0.00005 |
| Measles | 0.000005 | 0.000005 | 0.000005 | 0.00001 | 0.000005 | 0.00001 | 0.000005 | 0.000005 | 0.000005 | 0.000005 | 0.000005 |
| Other indirect | 0.000005 | 0.000005 | 0.000005 | 0.00001 | 0.000005 | 0.00001 | 0.000005 | 0.000005 | 0.000005 | 0.000005 | 0.000005 |
| **Total** | **0.000915** | **0.0006703** | **0.0006888** | **0.0006088** | **0.0006433** | **0.0007588** | **0.0008283** | **0.0007883** | **0.0011283** | **0.0006388** | **0.0007388** |

**TABLE B3:** RATES PER 1,000 POPULATION FOR DALYS

| | Average rural sites | Average urban sites | Average peri-urban sites | Site 1 Kunming urban | Site 2 Dali urban | Site 3 Qiubei urban | Site 4 Kunming rural | Site 5 Dali rural | Site 6 Qiubei rural | Site 7 Kunming peri-urban | Site 8 Dali peri-urban |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DIRECT DISEASES | | | | | | | | | | | |
| Mild diarrhea | 0.001490299 | 0.001105705 | 0.00115378 | 0.00087 | 0.0011538 | 0.001298 | 0.001298 | 0.0014422 | 0.001731 | 0.00101 | 0.001298 |
| Severe diarrhea | 0.003251833 | 0.002167889 | 0.00243887 | 0.00163 | 0.0016259 | 0.0032518 | 0.0016259 | 0.0016259 | 0.006504 | 0.001626 | 0.003252 |
| Helminthes | 0.006376066 | 0.006556106 | 0.00593634 | 0.00594 | 0.0059363 | 0.0077956 | 0.0065959 | 0.0059363 | 0.006596 | 0.005936 | 0.005936 |
| Hepatitis A, E | 1.25515E-05 | 1.25515E-05 | 1.2552E-05 | 0.00001 | 1.255E-05 | 1.255E-05 | 1.255E-05 | 1.255E-05 | 1.26E-05 | 1.26E-05 | 1.26E-05 |
| Scabies | 0.001126047 | 0.001126047 | 0.00112605 | 0.00113 | 0.001126 | 0.001126 | 0.001126 | 0.001126 | 0.001126 | 0.001126 | 0.001126 |
| Trachoma | 0.000578196 | 0.000578196 | 0.0005782 | 0.00058 | 0.0005782 | 0.0005782 | 0.0005782 | 0.0005782 | 0.000578 | 0.000578 | 0.000578 |
| INDIRECT DISEASES | | | | | | | | | | | |
| Malnutrition | 0.000114912 | 0.000114912 | 0.00011491 | 0.00011 | 0.0001149 | 0.0001149 | 0.0001149 | 0.0001149 | 0.000115 | 0.000115 | 0.00001 |
| Malaria | 0.001311462 | 2.62292E-05 | 6.5573E-06 | 0.00001 | 6.557E-05 | 6.557E-06 | 0.0013115 | 0.0013115 | 0.001311 | 6.56E-06 | 0.0000005 |
| ALRI | 0.001426817 | 0.001444999 | 0.00071341 | 0.00029 | 0.0007134 | 0.0033362 | 0.0014268 | 0.0014268 | 0.001427 | 0.000713 | 0.00005 |
| Measles | 5.24563E-05 | 5.24563E-05 | 5.2456E-05 | 0.00005 | 5.246E-05 | 5.246E-05 | 5.246E-05 | 5.246E-05 | 5.25E-05 | 5.25E-05 | 0.000005 |
| Other indirect | 5.24563E-05 | 5.24563E-05 | 5.2456E-05 | 0.00005 | 5.246E-05 | 5.246E-05 | 5.246E-05 | 5.246E-05 | 5.25E-05 | 5.25E-05 | 0.000005 |
| **Total** | **0.000915** | **0.0006703** | **0.0006888** | **0.0006088** | **0.0006433** | **0.0007588** | **0.0008283** | **0.0007883** | **0.0011283** | **0.0006388** | **0.0007388** |

**TABLE B4:** EVIDENCE ON TREATMENT SEEKING BEHAVIOR FOR OTHER DISEASES

| Data source | Observations | % seeking treatment from | | | | | No treatment | Total |
|---|---|---|---|---|---|---|---|---|
| | | Public provider | Private formal clinic | Informal care | Pharmacy | Self-treatment | | |
| RURAL AREAS | | | | | | | | |
| ESI sites (diarrheal disease only)[1] | 215 | 20 | 30 | 20 | 20 | 9 | 1 | 100 |
| Yunnan Province (all diseases)[2] | - | 41 | 30 | 10 | 10 | 9 | 1 | 100 |
| URBAN AREAS | | | | | | | | |
| ESI sites (diarrheal disease only)[1] | 185 | 40 | 10 | 20 | 10 | 20 | 0 | 100 |
| Yunnan Province (all diseases)[2] | - | 49 | 17 | 16 | 1 | 15 | 2 | 100 |
| PERI-URBAN AREAS | | | | | | | | |
| ESI sites (diarrheal disease only)[1] | 150 | 38 | 12 | 20 | 10 | 20 | 0 | 100 |

[1] Incidentals: non-health patient costs such as transport, food, and incidental expenses, per outpatient visit and per inpatient stay.
[2] ALOS: average length of stay.
[3] Inpatient health care costs are presented per stay.
Data source: "2009 China Health Statistics Yearbook", and supplemented by interviews with doctors and patients.

**TABLE B5:** UNIT COSTS ASSOCIATED WITH TREATMENT OF SEVERE DIARRHEA (US$, 2009)

| Health Provider | Outpatient cost (US$) | | Inpatient cost (US$) | | |
|---|---|---|---|---|---|
| | Health care | Incidentals[1] | ALOS[2] | Health care[3] | Incidentals[1] |
| PUBLIC/NGO | | | | | |
| Rural | 15.62 | 0.29 | 0.44 | 34.11 | 5.86 |
| Peri-urban | 15.62 | 0.73 | 0.44 | 39.23 | 4.68 |
| Urban | 15.62 | 0.73 | 0.44 | 39.23 | 2.93 |
| PRIVATE FORMAL | | | | | |
| Rural | 7.76 | 0.29 | 0.44 | 23.42 | 4.39 |
| Peri-urban | 11.71 | 0.73 | 0.44 | 26.35 | 2.93 |
| Urban | 13.61 | 0.73 | 0.44 | 26.35 | 2.20 |
| INFORMAL | | | | | |
| Rural | 4.39 | 0.73 | - | - | - |
| Peri-urban | 4.39 | 0.59 | - | - | - |
| Urban | 4.39 | 0.29 | - | - | - |

[1] Incidentals: non-health patient costs such as transport, food, and incidental expenses, per outpatient visit and per inpatient stay.
[2] ALOS: average length of stay.
[3] Inpatient health care costs are presented per stay.

# ANNEX C: WATER QUALITY IMPACT

**TABLE C1:** FULL WATER QUALITY MEASUREMENT RESULTS

| Sampling location | Uses | Distance from toilet | Temp. | pH | DO | COD | $NH_3$-N | TP | E. coli | $BOD_5$ | Con-duc-tivity | Tur-bidity | TN | $NO_3$-N | $NO_2$-N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| US1 | I | 500 | 15 | 7.9 | 7.54 | 17.12 | 0.015 | 0.06 | ≥24000 | 2L | 31 | 0.18 | 0.87 | 0.15 | 0.03L |
| US2 | I | 10 | 15 | 7.7 | 5.36 | 21.02 | 0.015 | 0.14 | ≥24000 | 2L | 34 | 0.21 | 2.18 | 0.33 | 0.03L |
| US3 | I | 10 | 17 | 7.6 | —— | 264.66 | 66.46 | 2.56 | ≥240000 | 140.7 | 123 | 2.4 | 61.22 | —— | —— |
| US4 | I | >1000 | 16 | 7.6 | 5.75 | 16.54 | 0.002 | 0.05 | ≥24000 | 2L | 39 | 0.27 | 1.35 | 0.43 | 0.03L |
| US5 | I | >1000 | 16 | 7.4 | —— | 124.54 | 13.474 | 2.44 | ≥240000 | 59 | 76 | 1.41 | 59.92 | —— | —— |
| US6 | I | >1000 | 16 | 7.7 | 5.65 | 21.22 | 0.015 | 0.1 | ≥24000 | 2.38 | 40 | 0.28 | 1.89 | 0.32 | 0.03L |
| US7 | I | 10 | 17 | 7.5 | 4.36 | 11.68 | 0.002 | 0.04 | ≥24000 | 2L | 38 | 0.25 | 1.04 | 0.44 | 0.03L |
| RS8 | L | 5 | 21 | 7.2 | 3.67 | 35.81 | 0.005 | 0.11 | 16000 | 5.11 | 53 | 0.46 | 2.4 | 0.29 | 0.03L |
| RS9 | L | 5 | 20 | 7 | 0.6 | 61.1 | 16.01 | 0.24 | ≥240000 | 20 | 75 | 0.76 | 14.65 | —— | —— |
| RS10 | IL | 5 | 20 | 7 | 1.59 | 35.03 | 0.002 | 0.13 | ≥24000 | 7.3 | 32 | 0.21 | 0.97 | 0.16 | 0.03L |
| RS11 | IL | 50 | 22 | 7.2 | 2.38 | 19.46 | 0.005 | 0.03 | 9200 | 5 | 28 | 0.21 | 0.68 | 0.17 | 0.03L |
| RS12 | IL | 50 | 24 | 7.2 | 3.08 | 23.35 | 0.005 | 0.03 | ≥24000 | 4 | 28 | 0.18 | 0.77 | 0.24 | 0.03L |
| RS13 | IL | >1000 | 23 | 8 | 7.04 | 12.65 | 0.015 | 0.03 | ≥24000 | 2L | 41 | 0.54 | 1.6 | 0.2 | 0.03L |
| RS14 | IL | >1000 | 22 | 8 | 7.39 | 11.68 | 0.018 | 0.04 | ≥24000 | 2L | 37 | 0.77 | 1.64 | 0.57 | 0.03L |
| Dingjia Shiqiao* | IL | 20 | 25 | 8.18 | 6.42 | 6.15 | 1.96 | 0.04 | 1700 | 2.4 | 21 | / | 1.61 | 0.96 | 0.036 |
| Puzhehei Qiaotou* | IL | >1000 | 27 | 7.54 | 3.88 | 5.33 | 0.28 | 0.03 | 16000 | 2L | 24 | / | 1.52 | 1.36 | 0.03L |
| Outlet of Puzhehei Lake* | I | >1000 | 27 | 8.01 | 7.77 | 5.74 | 0.44 | 0.01 | 1100 | 2L | 25 | / | 1.29 | 1.08 | 0.03L |

Note:
1. Unit for temperature is °C; no unit for pH, unit for E.coli is unit/L, unit for conductivity is mS/m, and unit for other items is mg/L; unit for distance between sampling points and nearest toilet is m.
2. "Detection limit + L" means that the result is lower than the detection limit.
3. Data marked with * are taken from routine monitoring by the same vendor from the monitoring report coded as HWJZ 2009-118. The parameters quoted here were measured with the same methods given in table 3.
4. I: irrigation; L: landscape

**TABLE C2:** WATER QUALITY MEASUREMENT RESULTS OF GROUND WATER

| Sampling location | Uses | Distance from toilet | Temp. | pH | $NH_3$-N | Conductivity | Turbidity | E.coli |
|---|---|---|---|---|---|---|---|---|
| UG1 | CBD | 5-10 | 20 | 6.8 | 0.002 | 92 | 0.12 | 9200 |
| UG2 | CBD | 5-10 | 21 | 7.1 | 0.002 | 62 | 0.09 | 2200 |
| UG3 | CBD | 5-10 | 22 | 6.6 | 0.002 | 63 | 0.12 | ≥24000 |
| UG4 | CBD | 5-10 | 19 | 6.4 | 0.002 | 73 | 2.58 | 20 |
| UG5 | CBD | 5-10 | 20 | 6.4 | 0.002 | 61 | 0.09 | ≥24000 |
| UG6 | CBD | 5-10 | 20 | 4.1 | 0.002 | 25 | 0.09 | 1800 |
| UG7 | CBD | 5-10 | 21 | 9 | 0.002 | 8 | 0.12 | 110 |
| UG8 | CBD | 5-10 | 19 | 6.9 | 0.002 | 7 | 0.14 | 90 |
| RG9 | CBD | 5-10 | 19 | 5.4 | 0.005 | 43 | 0.15 | 70 |
| RG10 | CBD | 5-10 | 21 | 6.3 | 0.005 | 42 | 0.09 | 9200 |
| RG11 | CBD | 5-10 | 20 | 5 | 0.004 | 101 | 0.12 | 170 |
| RG12 | CBD | 5-10 | 20 | 6.8 | 0.002 | 150 | 0.09 | 2400 |
| RG13 | CBD | 5-10 | 20 | 6.1 | 0.005 | 135 | 0.11 | ≥24000 |
| RG14 | CBD | 5-10 | 23 | 7 | 0.002 | 118 | 0.11 | 5400 |
| RG15 | CBD | 5-10 | 20 | 6.6 | 0.002 | 140 | 0.09 | ≥24000 |
| RT1 | CBD | 5 | 20 | 7 | 0.005 | 64 | 0.09 | 3500 |
| RT2 | CBD | 5 | 22 | 7 | 0.008 | 64 | 0.09 | 1600 |
| RSP1 | CBD | 500 | 19 | 6.8 | 0.002 | 64 | 0.09 | ≥24000 |
| RSP2 | CBD | >1000 | 20 | 7.1 | 0.005 | 60 | 0.12 | 2200 |

Note:
1. Unit for temperature is °C; no unit for pH, unit for E.coli is unit/L, unit for conductivity is mS/m, and unit for other items is mg/L; unit for distance between sampling points and nearest toilet is m.
2. "Detection limit + L" means that the result is lower than the detection limit.
3. C: cooking; B: bathing; D: drinking

**TABLE C3:** POLLUTION FROM POOR SANITATION AND WASTEWATER MANAGEMENT (% OF HOUSEHOLDS)

| Field sites | Human excreta management (%) | | | | | Household wastewater (%) | |
|---|---|---|---|---|---|---|---|
| | Not isolated | | Partial isolation | | Full isolation | Drain to ground | Drain to water sources |
| | OD | Flush to water | Dry pit | Wet pit | | | |
| U1 | 1.74% | 0 | 31.30% | 1.74% | 65.22% | 37.50% | 0 |
| R1 | 0.68% | 0 | 14.38% | 2.05% | 82.88% | 23.84% | 0 |
| PRU1 | 1.47% | 0 | 8.82% | 0.00% | 89.71% | 17.02% | 0 |
| U2 | 0.00% | 0 | 27.66% | 4.26% | 68.09% | 40.98% | 0 |
| R2 | 3.23% | 0 | 37.90% | 0.81% | 58.06% | 57.89% | 0 |
| PRU2 | 2.38% | 0 | 40.48% | 0.00% | 57.14% | 70.00% | 0 |
| U3 | 4.55% | 0 | 13.64% | 0.00% | 81.82% | 23.61% | 0 |
| R3 | 27.95% | 0 | 22.98% | 0.00% | 49.07% | 74.85% | 0 |
| **Average rural** | 7.44% | 0 | 15.63% | 0.60% | 40.48% | 52.97% | 0 |
| **Average peri-urban** | 1.14% | 0 | 13.07% | 0.00% | 48.30% | 32.84% | 0 |
| **Average urban** | 1.59% | 0 | 18.41% | 1.27% | 51.11% | 34.39% | 0 |
| **Total** | 1.59% | 0 | 18.41% | 1.27% | 51.11% | 34.39% | 0 |

Source: ESI Field Surveys

**TABLE C4:** WATER ACCESS AND COSTS (US$, 2009)

| Field site | Location | Piped water (treated) | | Non-piped protected source (including untreated piped) | | Non-piped unprotected source | |
|---|---|---|---|---|---|---|---|
| | | % access | Average monthly cost | % access | Average monthly cost | % access | Average monthly cost |
| U1 | Urban - Kunming | 98.29% | 39.91 | 0.85% | 15 | 0.85% | 30 |
| R1 | Rural - Luquan - Kunming | 85.26% | 14.95 | 10.26% | 27 | 4.49% | 25 |
| PRU1 | Peri-urban - Jinning, Kunming | 80.88% | 23.82 | 15.44% | 53.25 | 3.68% | 23.33 |
| U2 | Urban - Dali | 86.54% | 68.1 | 11.54% | 12 | 1.92% | 19.09 |
| R2 | Rural - Dali | 83.22% | 20.98 | 13.99% | 15 | 2.80% | 20 |
| PRU2 | Peri-urban - Zhoucheng, Dali | 98.33% | 10.85 | / | / | 1.67% | / |
| U3 | Urban - Qiubei | 88.41% | 1.06 | 4.35% | 0 | 7.25% | 0 |
| R3 | Rural - Qiubei | 29.05% | 14.91 | 37.16% | 18.04 | 33.78% | 13.64 |
| Average rural | | 66.00% | 16.46 | 20.36% | 19.06 | 13.65% | 6.3 |
| Average peri-urban | | 86.22% | 16.26 | 10.71% | 53.25 | 3.06% | 23.33 |
| Average urban | | 92.86% | 29.83 | 4.20% | 9 | 2.94% | 18.46 |
| Total | | 77.75% | 23.63 | 13.85% | 18.26 | 8.40% | 10.25 |

**TABLE C5:** HOUSEHOLDS CITING POOR WATER QUALITY FROM THEIR PRINCIPAL DRINKING WATER SOURCE

| Field site | Piped water (treated) | | | | Non-piped protected source (including untreated piped) | | | | Non-piped unprotected source | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bad appear-ance (%) | Bad smell (%) | Bad taste (%) | Contain solids (%) | Bad appear-ance (%) | Bad smell (%) | Bad taste (%) | Contain solids (%) | Bad appear-ance (%) | Bad smell (%) | Bad taste (%) | Contain solids (%) |
| U1 | 5.83% | 1.67% | 6.67% | 3.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| R1 | 1.99% | 0.00% | 1.32% | 3.97% | 0.00% | 0.66% | 0.00% | 0.66% | 0.00% | 0.66% | 0.00% | 0.66% |
| PRU1 | 1.42% | 0.71% | 2.13% | 0.71% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| U2 | 1.64% | 1.64% | 8.20% | 4.92% | 0.00% | 1.64% | 0.00% | 1.64% | 0.00% | 1.64% | 0.00% | 1.64% |
| R2 | 6.02% | 3.01% | 1.50% | 3.01% | 0.75% | 0.00% | 1.50% | 2.26% | 0.75% | 2.26% | 1.50% | 2.26% |
| PRU2 | 5.00% | 0.00% | 11.67% | 8.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| U3 | 8.33% | 0.00% | 0.00% | 9.72% | 0.00% | 0.00% | 0.00% | 1.39% | 0.00% | 1.39% | 0.00% | 1.39% |
| R3 | 4.09% | 0.00% | 0.00% | 2.34% | 4.68% | 0.00% | 3.51% | 15.20% | 7.60% | 14.62% | 3.51% | 14.62% |
| **Average rural** | 3.96% | 0.88% | 0.88% | 3.08% | 1.98% | 0.22% | 1.76% | 6.59% | 3.08% | 0.44% | 1.76% | 6.37% |
| **Average peri-urban** | 2.49% | 0.50% | 4.98% | 2.99% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **Average urban** | 5.53% | 1.19% | 5.14% | 5.53% | 0.00% | 0.40% | 0.00% | 0.79% | 0.00% | 0.40% | 0.00% | 0.79% |
| **Total** | **4.07%** | **0.88%** | **2.97%** | **3.74%** | **0.99%** | **0.22%** | **0.88%** | **3.52%** | **1.54%** | **0.33%** | **0.88%** | **3.41%** |

[1] Bad appearance covers bad color, or containing solids, sediments or particles

**TABLE C6:** HOUSEHOLD RESPONSES TO POLLUTED WATER – REASONS FOR USING WATER SOURCES

| Field site | Piped water (treated) | | | Non-piped protected source (including untreated piped) | | | Non-piped unprotected source | | |
|---|---|---|---|---|---|---|---|---|---|
| | Quality | Quantity | Cost | Quality | Quantity | Cost | Quality | Quantity | Cost |
| U1 | 42.86% | 32.38% | 24.76% | 0.00% | 100.00% | 0.00% | - | - | - |
| R1 | 53.02% | 31.63% | 15.35% | 47.62% | 38.10% | 14.29% | 90.00% | 0.00% | 10.00% |
| PRU1 | 45.93% | 39.26% | 14.81% | 51.61% | 32.26% | 16.13% | 84.62% | 0.00% | 15.38% |
| U2 | 57.38% | 34.43% | 8.20% | 50.00% | 25.00% | 25.00% | 66.67% | 16.67% | 16.67% |
| R2 | 58.18% | 28.18% | 13.64% | 72.97% | 21.62% | 5.41% | 83.33% | 16.67% | 0.00% |
| PRU2 | 39.18% | 32.99% | 27.84% | - | - | - | 0.00% | 100.00% | 0.00% |
| U3 | 51.46% | 33.98% | 14.56% | 50.00% | 33.33% | 16.67% | 71.43% | 28.57% | 0.00% |
| R3 | 48.39% | 45.16% | 6.45% | 63.16% | 28.95% | 7.89% | 58.82% | 32.94% | 8.24% |
| **Average rural** | 35.18% | 41.30% | 23.52% | 97.96% | 1.31% | 0.73% | 99.88% | 0.07% | 0.05% |
| **Average peri urban** | 47.47% | 37.35% | 15.18% | 91.24% | 6.57% | 2.19% | 99.01% | 0.77% | 0.22% |
| **Average urban** | 43.10% | 36.64% | 20.26% | 97.74% | 1.50% | 0.75% | 99.91% | 0.03% | 0.06% |
| **Total** | 41.95% | 38.75% | 19.30% | 95.87% | 2.95% | 1.18% | 99.62% | 0.28% | 0.10% |

**TABLE C7:** TREATMENT PRACTICES

| Field site | Boiling | Filtration | Deposition | Nothing |
|---|---|---|---|---|
| U1 | 88.33% | 0.83% | 0.00% | 10.83% |
| R1 | 83.44% | 0.66% | 0.66% | 15.23% |
| PRU1 | 87.23% | 0.71% | 1.42% | 10.64% |
| U2 | 68.85% | 1.64% | 1.64% | 27.87% |
| R2 | 90.23% | 0.00% | 0.00% | 9.77% |
| PRU2 | 91.67% | 0.00% | 0.00% | 8.33% |
| U3 | 56.94% | 1.39% | 1.39% | 40.28% |
| R3 | 59.06% | 0.00% | 0.00% | 40.94% |
| **Average Rural** | 76.26% | 0.22% | 0.22% | 23.30% |
| **Average Peri-urban** | 88.56% | 0.50% | 1.00% | 9.95% |
| **Average Urban** | 74.70% | 1.19% | 0.79% | 23.32% |
| **Total** | 78.55% | 0.55% | 0.55% | 20.35% |

**TABLE C8:** TREATMENT COSTS (US$, 2009)

| Field site | Boiling | Filtration | Decomposition |
|---|---|---|---|
| U1 | 9.20 | - | 8.75 |
| R1 | 8.77 | 3.00 | 8.00 |
| PRU1 | 16.97 | 32.00 | 14.00 |
| U2 | 8.75 | - | 12.50 |
| R2 | 8.50 | - | 9.85 |
| PRU2 | 15.00 | - | - |
| U3 | 10.00 | - | 10.00 |
| R3 | 6.00 | - | 4.50 |
| **Average rural** | 8.54 | - | 9.00 |
| **Average peri-urban** | 16.85 | 32.00 | 14.00 |
| **Average urban** | 8.94 | 3.00 | 9.55 |
| **Total** | 10.40 | 17.50 | 10.85 |

**TABLE C9:** WATER ACCESS AND HOUSEHOLD TREATMENT COSTS INCURRED AND AVERTED (US$, 2009)

| Variable | Annual average costs per household | | Annual average costs saved per household following 100% sanitation coverage | |
|---|---|---|---|---|
| | Water source access | Water treatment | Water source access | Water treatment |
| U1 | 305.00 | 472.55 | 29.70 | 51.10 |
| R1 | 516.72 | 193.01 | 6.40 | 48.80 |
| PRU1 | 825.00 | 316.80 | 7.20 | 47.60 |
| U2 | 577.97 | 594.00 | 0.70 | 47.70 |
| R2 | 522.60 | 244.56 | 23.60 | 47.80 |
| PRU2 | 212.63 | 130.19 | 16.60 | 48.20 |
| U3 | 820.26 | 12.24 | 12.20 | 49.70 |
| R3 | 671.51 | 188.45 | 7.30 | 40.20 |
| **Average rural** | 567.74 | 341.07 | 12.43 | 45.60 |
| **Average peri-urban** | 570.28 | 185.11 | 14.20 | 49.50 |
| **Average urban** | 518.82 | 215.88 | 11.90 | 47.90 |
| **Total** | 556.46 | 247.35 | 12.84 | 47.67 |

# ANNEX D: ACCESS TIME

**TABLE D1:** PLACE OF DEFECATION OF HOUSEHOLDS WITH NO "OWN" TOILET

| | Women | | | | Men | | | | Children | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Neighbor | Own plot | Outside plot | N | Neighbor | Own plot | Outside plot | N | Neighbor | Own plot | Outside plot |
| Site 1 Rural (Luquan), Kunming | 21 | 0 | 19 | 2 | 20 | 0 | 19 | 1 | 1 | 1 | 0 | 0 |
| Site 2 Rural in Dali | 12 | 5 | 7 | 0 | 12 | 5 | 7 | 0 | 0 | 0 | 0 | 0 |
| Site 3 Rural in Qiubei | 53 | 0 | 12 | 41 | 55 | 0 | 12 | 43 | 40 | 3 | 7 | 30 |
| Site 4 Urban in Kunming | 10 | 9 | 0 | 1 | 11 | 9 | 0 | 2 | 0 | 0 | 0 | 0 |
| Site 5 Urban in Dali | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Site 6 Urban in Qiubei | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 |
| Site 7 PRU (Jinglin) in Kunming | 12 | 0 | 11 | 1 | 12 | 0 | 11 | 1 | 1 | 1 | 0 | 0 |
| Site 8 PRU in Dali | 8 | 7 | 0 | 1 | 8 | 7 | 0 | 1 | 0 | 0 | 0 | 0 |
| **Average rural** | 28.7 | 1.7 | 13 | 14 | 29 | 1.7 | 12.7 | 14.7 | 13.7 | 1.3 | 2.3 | 10 |
| **Average urban** | 4.3 | 3 | 0 | 1.3 | 4.7 | 3 | 0 | 1.7 | 1 | 0 | 0 | 1 |
| **Average PRU** | 10 | 3.5 | 5.5 | 1 | 10 | 3.5 | 5.5 | 1 | 0.5 | 0.5 | 0 | 0 |

**TABLE D2:** DAILY TIME SPENT (MINUTES) ACCESSING TOILET FOR THOSE WITH NO TOILET

| | Women | | Men | | Children | |
|---|---|---|---|---|---|---|
| | Time per trip and waiting | No. of times per day | Time per trip and waiting | No. of times per day | Time per trip and waiting | No. of times per day |
| Site 1 Rural (Luquan) in Kunming | 7 | 3 | 7 | 3 | 7.7 | 4 |
| Site 2 Rural in Dali | 4 | 6.5 | 4 | 6.5 | 10 | 6 |
| Site 3 Rural in Qiubei | 8 | 3 | 8 | 3 | 7.6 | 4 |
| Site 4 Urban in Kunming | 0 | 5 | 0 | 5 | 0 | 5 |
| Site 5 Urban in Dali | 8 | 3 | 8 | 3 | 12.5 | 4 |
| Site 6 Urban in Qiubei | 4 | 4 | 4 | 4 | 5 | 5 |
| Site 7 PRU (Jinglin) in Kunming | 8 | 3 | 8 | 3 | 8.1 | 4 |
| Site 8 PRU in Dali | 0 | 5 | 0 | 5 | 11.3 | 6 |
| **Average rural** | 6.3 | 4.2 | 6.3 | 4.2 | 8.4 | 6 |
| **Average urban** | 3 | 4 | 3 | 4 | 5.8 | 4.7 |
| **Average PRU** | 4 | 4 | 4 | 4 | 9.6 | 5 |

**TABLE D3:** PRACTICES RELATED TO YOUNG CHILDREN

| | Parents accompanying young children | Of which: | |
|---|---|---|---|
| | | % outside plot | No. of times per day |
| R1 | 75 | 41.1 | 4 |
| R2 | 285 | 21.1 | 6 |
| R3 | 228 | 13.3 | 4 |
| U1 | 380 | 0 | 5 |
| U2 | 150 | 33.3 | 4 |
| U3 | 66 | 37.9 | 5 |
| PRU1 | 61 | 53.1 | 4 |
| PRU2 | 143 | 47.4 | 6 |
| Av. Rural | 196 | 25.7 | 6 |
| Av. Urban | 199 | 13.7 | 5 |
| Av. PRU | 102 | 47.1 | 5 |

**TABLE D4:** PREFERENCES RELATED TO TOILET CONVENIENCE, FROM HOUSEHOLD QUESTIONNAIRE

| Site | Perceived benefits of sanitation (B6.1): proximity cited as satisfied or very satisfied | | Those without toilet: reasons to get a toilet | |
|---|---|---|---|---|
| | Those with toilet | Those without toilet | Saves time (B7.16) | Proximity is an important characteristic (B7.17) |
| Site 1 Rural (Luquan) in Kunming | 3.4 | 3.0 | 5.0 | 5.0 |
| Site 2 Rural in Dali | 3.9 | | 4.4 | 4.6 |
| Site 3 Rural in Qiubei | 3.3 | 2.2 | 3.6 | 3.9 |
| Site 4 Urban in Kunming | 4.4 | 2.0 | 4.0 | 4.8 |
| Site 5 Urban in Dali | 3.1 | | | |
| Site 6 Urban in Qiubei | 4.1 | 1.0 | 4.5 | 4.5 |
| Site 7 PRU (Jinglin) in Kunming | 2.9 | 3.0 | 5.0 | 5.0 |
| Site 8 PRU in Dali | 4.4 | 1.0 | 3.0 | 5.0 |
| Average rural | 3.5 | 2.7 | 4.3 | 4.4 |
| Average urban | 3.9 | 1.5 | 4.3 | 4.7 |
| Average PRU | 3.7 | 2.0 | 4.0 | 5.0 |

**TABLE D5:** OPPORTUNITY COST OF TIME – WHAT RESPONDENTS WOULD SPEND AN EXTRA 30 MINS A DAY DOING (%)

| Ranking | Respondents with toilet (%) | Respondents with no toilet (%) |
|---|---|---|
| | FINDINGS FROM THE RURAL SITES | |
| Ranking 1 | Leisure 34.5% | Work/help to generate income/output/economic practice 5.7% |
| Ranking 2 | Work/help to generate income/output/economic practice 31.0% | Leisure 2.0% |
| Ranking 3 | Cleaning room, washing clothes, cleaning yard etc. 21.5% | Sleeping 1.5% |
| | FINDINGS FROM THE URBAN SITES | |
| Ranking 1 | Leisure 41.5% | Leisure 1.2% |
| Ranking 2 | Cleaning room, washing clothes, cleaning yard etc. 19.4% | Work/help to generate income/output/economic practice 0.8% |
| Ranking 3 | Sleeping 17.0% | Cleaning room, washing clothes, cleaning yard etc 0.8% |

**TABLE D6:** AVERAGE TIME SAVINGS PER YEAR, BY HOUSEHOLD MEMBER (US$, 2009)

| Site | Women | Men | Children | Adult time with young children | Per average household |
|---|---|---|---|---|---|
| Site 1 Rural (Luquan) in Kunming | 5.3 | 5.3 | 7.8 | 7.8 | 26.2 |
| Site 2 Rural in Dali | 6.6 | 6.6 | 15.2 | 15.2 | 43.6 |
| Site 3 Rural in Qiubei | 6.1 | 6.1 | 7.7 | 7.7 | 27.6 |
| Site 4 Urban in Kunming | 0 | 0 | 0 | 0 | 0 |
| Site 5 Urban in Dali | 6.1 | 6.1 | 12.7 | 12.7 | 37.6 |
| Site 6 Urban in Qiubei | 4.1 | 4.1 | 6.3 | 6.3 | 20.8 |
| Site 7 PRU (Jinglin) in Kunming | 6.1 | 6.1 | 8.2 | 8.2 | 28.6 |
| Site 8 PRU in Dali | 0 | 0 | 17. 2 | 17.2 | 34.4 |
| Average rural | 6 | 6 | 12.8 | 12.8 | 37.6 |
| Average urban | 5.1 | 5.1 | 6.9 | 6.9 | 24 |
| Average PRU | 6.1 | 6.1 | 12.2 | 12.2 | 36.6 |

**TABLE D7:** AVERAGE ANNUAL VALUE OF TIME SAVINGS (US$, 2009)

| Site | Women | Men | Children | Adult time with young children | Per average household |
|---|---|---|---|---|---|
| Site 1 Rural (Luquan) in Kunming | 134 | 134 | 99 | 99 | 466 |
| Site 2 Rural in Dali | 169 | 169 | 195 | 195 | 728 |
| Site 3 Rural in Qiubei | 132 | 132 | 83 | 83 | 430 |
| Site 4 Urban in Kunming | 0 | 0 | 0 | 0 | 0 |
| Site 5 Urban in Dali | 156 | 156 | 163 | 163 | 638 |
| Site 6 Urban in Qiubei | 88 | 88 | 68 | 68 | 312 |
| Site 7 PRU (Jinglin) in Kunming | 143 | 143 | 96 | 96 | 478 |
| Site 8 PRU in Dali | 0 | 0 | 220 | 220 | 440 |
| Average rural | 145 | 145 | 126 | 126 | 542 |
| Average urban | 122 | 122 | 116 | 116 | 476 |
| Average PRU | 143 | 143 | 158 | 158 | 602 |

# ANNEX E: INTANGIBLE USER PREFERENCES FOR SANITATION

**TABLE E1:** RESPONDENTS' UNDERSTANDING OF SANITATION - TOP RANKED RESPONSES PER SITE

| | Household interview | Focus Group Discussions | | | |
|---|---|---|---|---|---|
| | | With sanitation | | Without sanitation | |
| | | Men | Women | Men | Women |
| **Average rural** | 1. flush toilet connected to sewerage 17%<br>2. private toilet 7%<br>3. toilet built in yard or near the residence 4% | 1. improved pit-latrine 18.3%<br>2. 3-in-1 biogas unit 11.3%<br>3. UDDT 10% | 1. improved pit-latrine 19.7%<br>2. 3-in-1 biogas unit 18.6%<br>3. UDDT 10.3% | 1. shared toilet 4.3%<br>2. improved pit latrine 3%<br>3. flush toilet with septic tank or sewerage 1.3% | 1. shared toilet 5.7%<br>2. improved pit latrine 3.3%<br>3. UDDT 0.7% |
| **Average urban** | 1. flush toilet connected to sewerage 6%<br>2. improved public toilet 2.3%<br>3. toilet building near the yard or house 1.7% | 1. flush toilet (connected to septic tank and sewerage) 20.3%<br>2. public toilet 7.3%<br>3. improved pit-latrine 1.7% | 1. flush toilet connected to septic tank and sewerage 26.7%<br>2. public toilet 8.7%<br>3. improved pit latrine 6.3% | 1. flush toilet connected to septic tank and sewerage 22.7%<br>2. public toilet 9.7%<br>3. improved pit-latrine 7.3% | 1. flush toilet connected to septic tank and sewerage 27.6%<br>2. public toilet 10%<br>3. flush toilet 10.3% |
| **Average peri-urban** | 1. improved flush toilet 9%<br>2. improved public toilet 6.5%<br>3. toilet installed in the house 5% | 1. flush toilet connected to septic tank and swerage 20%<br>2. public flush toilet 10%<br>3. UDDT 4% | 1. flush toilet connected to septic tank and sewerage 19%<br>2. public flush toilet 12%<br>3. UDDT 5.5%<br>4. 3-in-1 biogas unit 5.5% | 1. flush toilet connected to septic tank and sewerage 19%<br>2. public flush toilet 10%<br>3. UDDT 4% | 1. flush toilet connected to septic tank 22%<br>2. public flush toilet 11.5%<br>3. UDD 10% |

**TABLE E2:** REASONS FOR CURRENT SANITATION COVERAGE – TOP 3 RANKED RESPONSES PER SITE

| | Household interview | Focus Group Discussions | | | |
|---|---|---|---|---|---|
| | | Why families with toilet have a toilet | | Why families without toilet do not have a toilet | |
| | | Men (accounting for heads) | Women (accounting for heads) | Men (accounting for heads) | Women (accounting for heads) |
| **Average rural** | 1. Privacy of toilet 44%<br>2. Proximity to the house 34%<br>3. use toilet on rainy days 17%<br>4. Comfortable location 10%<br>5. avoid snakes and pests 8% | 1. clean19%<br>2. convenient and safe19%<br>3. protect the headwater 18.3%<br>4. alone and not being disturbed 6%<br>5. health 3% | 1. clean 22%<br>2. convenient and safe 15.3%<br>3. protect the headwater 21.7%<br>4. health 13.3%<br>5. save energy 8.3% | 1. high cost 1%<br>2. no space 0.7%<br>3. incapable 0.7%<br>4. never considered this 0.7%<br>5. no one provided facility 3.3% | 1. high cost 5.7%<br>2. no space 2.7%<br>3. incapable 1.3%<br>4. never considered this 3.3%<br>5. no one provided facility 2.6% |
| **Average urban** | 1. Privacy of toilet 27%<br>2. Avoid snakes and pests 26%<br>3. convenient for using on rainy days 23%<br>4. Proximity to house 18%<br>5. comfortable location 11% | 1. convenience, sanitary 8.3%<br>2. environment protection 8.3%<br>3. safety 5.7%<br>4. health 3%<br>5. civilized 2% | 1. safety 10.7%<br>2. convenience, sanitary 10%<br>3. environment protection 7.3%<br>4. health 7.3%<br>5. civilized 3% | 1. limited by location 8%<br>2. limited by money 8%<br>3. limited by city planning 8% | 1. limited by location 12%<br>2. limited by money 12%<br>3. limited by city planning 12% |
| **Average peri-urban** | 1. privacy of toilet 33%<br>2. avoid snakes and pests 19%<br>3. showering in the toilet 19%<br>4. comfortable location 7%<br>5. proximity to the house 6% | 1. convenience 8.5<br>2. sanitary 8.5<br>3. environment protection 8.5<br>4. safety 8<br>5. comfort 7 | 1. convenience 10%<br>2. sanitary 10%<br>3. environment protection 10%<br>4. safety 10%<br>5. comfort 6% | 1. no space 10%<br>2. incapable 10%<br>3. use public toilet 10%<br>4. live in rented room 10%<br>5. not necessary 10% | 1. no space 11%<br>2. incapable 11%<br>3. use public toilet 11%<br>4. live in rented room 11%<br>5. not necessary 10% |

**TABLE E3:** LEVEL OF SATISFACTION WITH CURRENT TOILET OPTION, BY OPTION TYPE (1 = NOT SATISFIED; 5 = VERY SATISFIED)

| Characteristic | Those with improved sanitation | | | | | Those with unimproved sanitation | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sewer/ septic tank | Wet pit latrine | Dry pit latrine | Compost toilet | Average | Unimproved pit or bucket | Shared toilet | No toilet | Average |
| Toilet position | 3.3 | 3.6 | 4.0 | 3.7 | 3.7 | 1.5 | 3.2 | 1.9 | 2.2 |
| Cleanliness | 3.2 | 3.4 | 3.8 | 3.4 | 3.5 | 1.5 | 3.1 | 2.1 | 2.2 |
| Status | 3.3 | 3.4 | 3.7 | 3.5 | 3.5 | 1.0 | 2.9 | 1.8 | 1.9 |
| Visitors | 3.4 | 3.3 | 3.6 | 3.0 | 3.3 | 1.0 | 2.9 | 1.8 | 1.9 |
| Maintaining | 3.4 | 3.5 | 3.8 | 3.5 | 3.6 | 1.0 | 3.2 | 2.2 | 2.1 |
| Health | 3.2 | 3.4 | 4.1 | 3.3 | 3.5 | 1.0 | 3.1 | 1.8 | 2.0 |
| Conflict avoidance | 3.3 | 3.4 | 4.1 | 3.8 | 3.7 | 1.5 | 3.0 | 2.2 | 2.2 |
| Convenience for children | 3.4 | 3.2 | 4.2 | 3.5 | 3.6 | 1.0 | 3.0 | 1.7 | 1.9 |
| Convenience for elderly | 3.3 | 3.4 | 4.2 | 3.4 | 3.6 | 1.0 | 3.0 | 2.0 | 2 |
| Night use of toilet | 3.1 | 3.4 | 4.0 | 3.4 | 3.5 | 1.0 | 2.9 | 1.8 | 1.9 |
| Avoid rain | 3.0 | 3.3 | 4.1 | 3.4 | 3.5 | 1.0 | 2.8 | 1.7 | 1.8 |
| Showering | 3.8 | 3.8 | 4.2 | 3.5 | 3.8 | 1.0 | 2.7 | 1.8 | 1.8 |
| Dangerous animals | 3.3 | 3.4 | 3.8 | 3.2 | 3.4 | 1.0 | 3.1 | 2.0 | 2.0 |

Source : Household interviews

**TABLE E4:** IMPORTANT CHARACTERISTICS OF A TOILET FOR THOSE CURRENTLY WITHOUT (1=NOT IMPORTANT; 5= VERY IMPORTANT)

| Characteristic | No. responses | Average score |
|---|---|---|
| Comfortable toilet position | 77 | 4.2 |
| Cleanliness and freedom from unpleasant odors and insects | 79 | 4.0 |
| Having a toilet not needing to share with other households | 77 | 3.6 |
| Having privacy when at the toilet | 77 | 4.2 |
| Proximity of toilet to house | 71 | 4.2 |
| Pour-flush compared to dry pit latrine | 64 | 3.2 |
| Having a toilet disposal system that does not require emptying (piped sewer vs septic tank) | 70 | 3.4 |
| Having a toilet disposal system that does not pollute your, neighbors', or your community's environment | 67 | 3.6 |
| Preferred type of toilet households would like to get | 72 | 5.6% dry pit |
| | | 38.9% wet pit |

# ANNEX F: EXTERNAL ENVIRONMENT

**TABLE F1:** SCORING OF DIFFERENT TYPES OF LIVING AREA (1 = CLEAN; 2 = MINOR SOILING; 3 = MODERATE SOILING; 4 = MAJOR SOILING; 5 = EXTREME SOILING)

| Site | Private plots | | Community living areas (market, roadside) |
|---|---|---|---|
| | Human excreta | Animal excreta | Human excreta & Animal excreta & Solid waste |
| U1 (Urban: Kunming) | 2.83 | 3.47 | 3.30 |
| R1 (Rural-Luquan: Kunming) | 2.28 | 4.02 | 2.68 |
| PRU1 (Peri-urban-Jinning: Kunming) | 2.34 | 3.60 | 2.69 |
| U2 (Urban: Dali) | 2.39 | 3.44 | 2.88 |
| R2 (Rural: Dali) | 2.59 | 3.92 | 3.07 |
| PRU2 (Peri-urban-Zhoucheng: Dali) | 3.47 | 3.64 | 3.03 |
| U3 (Urban: Qiubei) | 3.30 | 3.67 | 2.57 |
| R3 (Rural: Qiubei) | 2.79 | 4.45 | 3.52 |
| **Average rural** | **2.53** | **4.13** | **3.09** |
| **Average urban** | **2.84** | **3.52** | **2.91** |
| **Average peri-urban** | **2.9** | **3.6** | **2.86** |
| **TOTAL** | **2.76** | **3.75** | **2.95** |

Source of data: for private plots - ESI household observation instrument; for community areas - physical location survey.

**TABLE F2:** PROPORTION OF HOUSEHOLDS WITH AND WITHOUT TOILET WITH UNIMPROVED SANITATION PRACTICE

| Site | Households with toilet | | Households with no toilet | |
|---|---|---|---|---|
| | Open defecation and urination | Seen others or own children defecating in yard[2] | Disposal of own child's stool in environment last time they defecated[1] | Seen others or own children defecating in yard[2] |
| U1(Urban- Kunming) | 4.00% | 29.4% | Data could not be identified | 64.29% |
| R1(Rural-Luquan, Kunming) | 14.71% | 41.3% | Data could not be identified | 40.00% |
| PRU1 (Peri-urban-Jinning,Kunming) | 33.33% | 42.5% | Data could not be identified | 66.67% |
| U2 (Urban—Dali) | 25.00% | 38.9% | Data could not be identified | 66.67% |
| R2 (Rural-Dali) | 2.38% | 16.7% | 33.3% | 41.7% |
| PRU2 (Peri-urban-Zhoucheng, Dali) | 0.00% | 66.7% | 0.0% | 91.7% |
| U3 (Urban-Qiubei) | 1.04% | 87.9% | 14.29% | 44.4% |
| R3 (Rural-Qiubei) | 3.53% | 85.7% | Data could not be identified | 50.0% |
| **Average rural** | 3.44% | 43.0% | Data could not be identified | 68.82% |
| **Average urban** | 4.04% | 51.0% | Data could not be identified | 35.76% |
| **TOTAL** | 3.60% | 48.0% | Data could not be identified | 48.36% |

[1] Answering "put in drain or ditch," "thrown out garbage," "buried in ground" and "left out in open")
[2] Answering "sometimes" or "often"

**TABLE F3:** IMPLICATION OF CURRENT TOILET OPTION FOR EXTERNAL ENVIRONMENT (1 = NOT SATISFIED; 5 = VERY SATISFIED)

| Characteristic | Improved sanitation | | | | | | | Unimproved sanitation | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Private sewer-age | Pour-flush private septic tank | Private wet pit | Three-com-partment septic tank | 3- in-1 biogas septic tank latrine | Private ecosan | Average | Shared toilet | OD | Average |
| U1 | 3.93 | 4.50 | 3.91 | 4.10 | 2.50 | 3.33 | 4.26 | N/A | 2.00 | 2.00 |
| U2 | 3.40 | 3.31 | 3.36 | 2.22 | 4.00 | 3.00 | 3.10 | 3.00 | N/A | 3.00 |
| U3 | 4.17 | 4.00 | 3.00 | 3.00 | N/A | 4.50 | 4.06 | 4.00 | 2.00 | 3.33 |
| R1 | 3.06 | 4.00 | 3.53 | 3.69 | N/A | 3.00 | 3.45 | N/A | 3.00 | 3.00 |
| R2 | N/A | 4.00 | 3.64 | 3.50 | 3.74 | 3.33 | 3.47 | 3.17 | N/A | 2.11 |
| R3 | 5.00 | 3.25 | 2.70 | N/A | 3.75 | 3.91 | 3.47 | 3.25 | 2.63 | 2.75 |
| PRU1 | 2.47 | 2.98 | 2.00 | 2.00 | 4.00 | N/A | 2.75 | 2.98 | 3.00 | 2.98 |
| PRU2 | N/A | 4.18 | 4.06 | 4.25 | 3.50 | 3.00 | 4.33 | 4.18 | 1.00 | 4.00 |
| **Average rural** | **4.03** | **3.75** | **3.29** | **3.60** | **3.75** | **3.41** | **3.46** | **3.21** | **2.82** | **2.62** |
| **Average urban** | **3.83** | **3.94** | **3.42** | **3.11** | **3.25** | **3.61** | **3.81** | **3.50** | **2.00** | **2.78** |
| **Peri-urban** | **2.47** | **3.58** | **3.03** | **3.13** | **3.75** | **3.00** | **3.54** | **3.58** | **2.00** | **3.49** |
| **TOTAL** | **3.67** | **3.78** | **3.28** | **3.25** | **3.58** | **3.44** | **3.61** | **3.43** | **2.27** | **2.90** |
| *Sample size* | 83 | 229 | 137 | 140 | 65 | 14 | | 120 | 54 | |

Source : Household interviews

**TABLE F4:** PERCEPTIONS OF ENVIRONMENTAL SANITATION STATE, BY OPTION TYPE (1 = VERY BAD; 5 = VERY GOOD)

| Site | Perception of environmental sanitation state | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rubbish | Sewage | Standing water | Smoke | Smell | Dirt outside | Dirt inside | Rodents | Insects |
| U1 (Urban- Kunming) | 2.70 | 2.57 | 2.79 | 2.97 | 2.71 | 2.76 | 3.03 | 2.92 | 2.87 |
| R1 (Rural-Luquan, Kunming) | 3.32 | 3.13 | 3.17 | 3.59 | 3.29 | 3.19 | 3.34 | 3.47 | 3.27 |
| PRU1 (Peri-urban-Jinning, Kunming) | 3.31 | 3.15 | 3.20 | 3.63 | 3.29 | 3.13 | 3.32 | 3.53 | 3.28 |
| U2 (Urban - Dali) | 3.12 | 2.72 | 2.93 | 3.22 | 2.95 | 2.98 | 3.25 | 3.03 | 3.00 |
| R2 (Rural-Dali) | 2.93 | 2.80 | 2.84 | 3.02 | 2.87 | 2.82 | 2.99 | 2.79 | 2.67 |
| PRU2 (Peri-urban-Zhoucheng, Dali) | 2.97 | 2.93 | 3.07 | 3.12 | 3.07 | 3.17 | 3.25 | 3.28 | 3.22 |
| U3 (Urban-Qiubei) | 3.43 | 3.42 | 3.42 | 3.51 | 3.42 | 3.48 | 3.54 | 3.48 | 3.52 |
| R3 (Rural-Qiubei) | 2.48 | 2.54 | 2.78 | 2.84 | 2.49 | 2.71 | 2.71 | 2.51 | 2.53 |
| **Av. Rural** | **2.89** | **2.81** | **2.92** | **3.14** | **2.86** | **2.90** | **3.00** | **2.91** | **2.82** |
| **Av. Urban** | **3.09** | **2.95** | **3.07** | **3.31** | **3.08** | **3.07** | **3.25** | **3.26** | **3.16** |
| **TOTAL** | **2.99** | **2.88** | **3.00** | **3.22** | **2.97** | **2.99** | **3.12** | **3.08** | **2.99** |

**TABLE F5:** RANKING THE IMPORTANCE OF ENVIRONMENTAL SANITATION, BY OPTION TYPE (1 = NOT IMPORTANT; 5 = VERY IMPORTANT)

| Site | Perceived importance of environmental sanitation management | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rubbish | Sewage | Water | Smoke | Smell | Dirt outside | Dirt inside | Rodents | Insects |
| U1 (Urban- Kunming) | 4.41 | 4.32 | 4.23 | 4.18 | 4.39 | 4.19 | 4.10 | 4.24 | 4.32 |
| R1 (Rural-Luquan, Kunming) | 4.49 | 4.22 | 4.07 | 4.23 | 4.42 | 4.29 | 4.14 | 4.54 | 4.53 |
| PRU1 (Peri-urban-Jinning, Kunming) | 4.53 | 4.25 | 4.10 | 4.21 | 4.39 | 4.31 | 4.17 | 4.42 | 4.39 |
| U2 (Urban - Dali) | 4.30 | 4.03 | 3.82 | 3.86 | 4.19 | 4.10 | 3.72 | 4.41 | 4.34 |
| R2 (Rural-Dali) | 3.89 | 3.97 | 3.92 | 3.84 | 4.03 | 3.87 | 3.77 | 4.09 | 4.18 |
| PRU2 (Peri-urban-Zhoucheng, Dali) | 4.78 | 4.53 | 4.52 | 4.55 | 4.67 | 4.48 | 4.38 | 4.45 | 4.55 |
| U3 (Urban-Qiubei) | 4.13 | 4.15 | 4.01 | 4.12 | 4.09 | 4.00 | 4.01 | 4.19 | 4.21 |
| R3 (Rural-Qiubei) | 4.11 | 3.95 | 3.78 | 3.75 | 4.18 | 3.86 | 3.81 | 4.42 | 4.50 |
| **Av. Rural** | **4.17** | **4.05** | **3.92** | **3.93** | **4.21** | **4.00** | **3.91** | **4.36** | **4.42** |
| **Av. Urban** | **4.44** | **4.26** | **4.14** | **4.19** | **4.35** | **4.23** | **4.09** | **4.34** | **4.36** |
| **TOTAL** | **4.30** | **4.15** | **4.03** | **4.06** | **4.28** | **4.11** | **4.00** | **4.35** | **4.39** |

# ANNEX G: COST TABLES

**TABLE G1:** AVERAGE RURAL COST PER HOUSEHOLD FOR DIFFERENT SANITATION AND HYGIENE OPTIONS, USING FULL (ECONOMIC) COST (US$, YEAR 2009)

| Cost Item | Hygiene | Shared | Pit | UDDT | Biogas | Septic |
|---|---|---|---|---|---|---|
| INVESTMENT COSTS: INITIAL ONE-OFF SPENDING | | | | | | |
| 1. Capital | 33.4 | 134.7 | 159.1 | 165.7 | 336.0 | 484.0 |
| 2. Program | 2.9 | 0.0 | 0.0 | 19.0 | 25.5 | 23.3 |
| **Sub-total** | 36.3 | 134.7 | 159.1 | 184.7 | 361.4 | 507.4 |
| RECURRENT COSTS: AVERAGE ANNUAL SPENDING | | | | | | |
| 3. Operation | 5.4 | 4.4 | 5.3 | 5.7 | 10.4 | 15.4 |
| 4. Maintenance | 6.6 | 11.4 | 14.1 | 14.6 | 16.8 | 21.2 |
| 5. Program | 2.9 | 0.0 | 0.0 | 4.4 | 4.4 | 6.0 |
| **Sub-total** | 15.1 | 15.8 | 19.3 | 24.7 | 31.6 | 42.6 |
| AVERAGE ANNUAL COST CALCULATIONS | | | | | | |
| Duration | 5.0 | 10.0 | 10.0 | 10.0 | 10.0 | 20.0 |
| Cost/household | 22.3 | 29.2 | 35.3 | 43.2 | 67.8 | 68.0 |
| Cost/capita | 6.4 | 8.3 | 10.1 | 12.3 | 19.4 | 19.4 |
| OF WHICH: | | | | | | |
| % capital | 0.3 | 0.5 | 0.5 | 0.4 | 0.5 | 0.4 |
| % program | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % recurrent | 0.7 | 0.5 | 0.5 | 0.6 | 0.5 | 0.6 |
| *Observations* | 403.0 | 14.0 | 118.0 | 14.0 | 43.0 | 214.0 |

**TABLE G2:** AVERAGE URBAN COST PER HOUSEHOLD FOR DIFFERENT SANITATION AND HYGIENE OPTIONS, USING FULL (ECONOMIC) COST (US$, YEAR 2009)

| Cost Item | Hygiene | Shared | Public toilet | Pit | UDDT | Septic | Septage optimal | Septage actual | Sewer-age optimal | Sewer-age actual |
|---|---|---|---|---|---|---|---|---|---|---|
| INVESTMENT COSTS: INITIAL ONE-OFF SPENDING | | | | | | | | | | |
| 1. Capital | 37.9 | 133.2 | 187.4 | 164.0 | 168.3 | 497.9 | 537.2 | 571.7 | 629.9 | 653.3 |
| 2. Program | 2.9 | 4.4 | 13.9 | 0.0 | 20.5 | 24.2 | 27.8 | 30.7 | 29.4 | 31.3 |
| **Sub-total** | 40.8 | 137.6 | 201.3 | 164.0 | 188.8 | 522.2 | 565.1 | 602.4 | 659.3 | 684.8 |
| RECURRENT COSTS: AVERAGE ANNUAL SPENDING | | | | | | | | | | |
| 3. Operation | 6.6 | 5.9 | 14.6 | 5.9 | 7.3 | 18.4 | 24.2 | 24.6 | 27.8 | 28.4 |
| 4. Maintenance | 9.1 | 8.1 | 8.8 | 13.8 | 17.6 | 23.3 | 31.5 | 32.2 | 40.1 | 41.1 |
| 5. Program | 2.9 | 2.2 | 5.1 | 0.0 | 4.4 | 4.4 | 4.4 | 4.8 | 4.4 | 4.7 |
| **Sub-total** | 18.4 | 16.1 | 28.5 | 19.6 | 29.3 | 46.0 | 60.0 | 61.6 | 72.3 | 74.2 |
| AVERAGE ANNUAL COST CALCULATIONS | | | | | | | | | | |
| Duration | 5.0 | 10.0 | 10.0 | 10.0 | 10.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| Cost/household | 26.6 | 29.9 | 48.7 | 35.9 | 48.2 | 72.1 | 88.3 | 91.7 | 105.2 | 108.5 |
| Cost/capita | 7.6 | 8.5 | 13.9 | 10.3 | 13.8 | 20.6 | 25.2 | 26.2 | 30.1 | 31.0 |
| OF WHICH: | | | | | | | | | | |
| % capital | 0.3 | 0.4 | 0.4 | 0.5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| % program | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % recurrent | 0.7 | 0.5 | 0.6 | 0.5 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 |
| *Observations* | 257.0 | 2.0 | 16.0 | 26.0 | 3.0 | 156.0 | 10.0 | 10.0 | 44.0 | 44.0 |

**TABLE G3:** AVERAGE PERI-URBAN COST PER HOUSEHOLD FOR DIFFERENT SANITATION AND HYGIENE OPTIONS, USING FULL (ECONOMIC) COST (US$, YEAR 2009)

| Cost Item | Hygiene | Shared | Pit | UDDT | Septic |
|---|---|---|---|---|---|
| INVESTMENT COSTS: INITIAL ONE-OFF SPENDING | | | | | |
| 1. Capital | 37.6 | 135.3 | 166.7 | 169.2 | 498.3 |
| 2. Program | 2.9 | 0.0 | 0.0 | 17.0 | 24.6 |
| **Sub-total** | 40.5 | 135.3 | 166.7 | 186.4 | 522.9 |
| RECURRENT COSTS: AVERAGE ANNUAL SPENDING | | | | | |
| 3. Operation | 6.9 | 5.9 | 5.9 | 7.9 | 18.3 |
| 4. Maintenance | 8.3 | 11.4 | 14.8 | 15.8 | 22.7 |
| 5. Program | 2.9 | 0.0 | 0.0 | 4.4 | 4.4 |
| **Sub-total** | 18.2 | 17.3 | 20.6 | 28.3 | 45.4 |
| AVERAGE ANNUAL COST CALCULATIONS | | | | | |
| Duration | 5.0 | 10.0 | 10.0 | 10.0 | 20.0 |
| Cost/household | 26.3 | 30.8 | 37.3 | 46.8 | 71.5 |
| Cost/capita | 7.5 | 8.8 | 10.7 | 13.4 | 20.4 |
| OF WHICH: | | | | | |
| % capital | 0.3 | 0.4 | 0.4 | 0.4 | 0.3 |
| % program | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % recurrent | 69.1 | 56.0 | 55.4 | 60.2 | 63.5 |
| *Observations* | 199 | 71 | 29 | 24 | 75 |

**TABLE G4:** PROPORTION OF TOTAL (ECONOMIC) COSTS WHICH ARE FINANCIAL (US$, YEAR 2009)

| Sanitation Options | | Hygiene | Shared | Public toilet | Pit latrine | UDDT | Biogas | Septic tank | Septage optimal | Septage actual | Sewer-age optimal | Sewer-age actual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capital (total) | Financial | 20.5 | 89.3 | 143.5 | 110.8 | 123.6 | 282.5 | 421.2 | 453.8 | 481.6 | 534.3 | 553.2 |
| | Total | 35.7 | 135.1 | 187.4 | 161.2 | 168.1 | 336.0 | 491.3 | 537.2 | 571.7 | 629.9 | 653.3 |
| | Proportion | 0.6 | 0.7 | 0.8 | 0.7 | 0.7 | 0.8 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 |
| Program (total) | Financial | 1.5 | 0.0 | 10.2 | 0.0 | 14.3 | 21.1 | 18.6 | 20.5 | 22.7 | 21.7 | 23.0 |
| | Total | 2.9 | 0.1 | 13.9 | 0.0 | 18.0 | 25.5 | 23.9 | 27.8 | 30.7 | 29.4 | 31.3 |
| | Proportion | 0.5 | | 0.7 | | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 |
| Recurrent (annual) | Financial | 11.0 | 7.6 | 17.6 | 8.8 | 12.9 | 15.7 | 19.6 | 29.3 | 30.3 | 34.8 | 35.9 |
| | Total | 16.8 | 17.0 | 28.5 | 19.6 | 27.1 | 31.6 | 44.2 | 60.0 | 61.6 | 72.3 | 74.2 |
| | Proportion | 0.7 | 0.5 | 0.6 | 0.4 | 0.5 | 0.5 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 |
| Average (annual) | Financial | 15.4 | 16.6 | 32.9 | 19.9 | 26.6 | 46.0 | 41.6 | 53.0 | 55.5 | 62.6 | 64.6 |
| | Total | 24.5 | 30.5 | 48.7 | 35.7 | 45.7 | 67.8 | 70.0 | 88.3 | 91.7 | 105.2 | 108.5 |
| | Proportion | 0.6 | 0.5 | 0.7 | 0.6 | 0.6 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Duration (years) | | 5.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |

**TABLE G5:** INCREMENTAL COSTS OF MOVING UP THE SANITATION LADDER (US$, 2009)

| | Hygiene | Shared | Pit latrine | UDDT | Biogas | Septic tank | Public toilet with sewerage | Sewerage actual |
|---|---|---|---|---|---|---|---|---|
| Duration | 5.0 | 10.0 | 10.0 | 10.0 | 10.0 | 20.0 | 20.0 | 20.0 |
| Sub-total investment | 40.8 | 136.3 | 161.2 | 185.9 | 361.4 | 515.1 | 201.3 | 684.8 |
| Sub-total annual recurrent | 17.7 | 17.4 | 19.6 | 27.1 | 31.6 | 44.2 | 28.5 | 74.2 |
| Total economic costs | 129.6 | 310.2 | 357.0 | 456.7 | 677.6 | 1,400.5 | 772.2 | 2,169.9 |
| | | Shared | Pit latrine | UDDT | Biogas | Septic tank | Public toilet with sewerage | Sewerage actual |
| Shared | | - | 357.0 | 456.7 | 677.6 | 1,400.5 | 772.2 | 2,169.9 |
| Pit latrine | | - | - | 456.7 | 200.4 | 1,400.5 | 772.2 | 2,169.9 |
| UDDT | | - | - | - | 677.6 | 1,400.5 | 772.2 | 2,169.9 |
| Biogas | | - | - | - | - | 1,400.5 | 772.2 | 2,169.9 |
| Septic tank | | - | - | - | - | - | 772.2 | 769.3 |
| Public toilet with sewerage | | - | - | - | - | - | - | 2,169.9 |

# ANNEX H: PROGRAM APPROACH ANALYSIS

**TABLE H1:** HOUSEHOLD CHOICES AND OTHER INTERVENTIONS

| Site | Rural/ urban | Number of households interviewed | Was household given a choice to participate? (%) | | Was household given a choice of options (%) | | Hygiene awareness (%) | | Water intervention offered (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yes, voluntary | No, not voluntary | Yes, choice available | No, choice not available | Yes | No | Yes | No |
| 1. Kunming | Rural | 151 (54) | 9.9% | 25.8% | 4.6% | 31.1% | 10.6% | 24.5% | 28.5% | 7.3% |
| 2. Dali | Rural | 133 (59) | 15% | 29.3% | 14.3% | 30.1% | 24.8% | 19.5% | 9% | 35.3% |
| 3. Qiubei | Rural | 171 (75) | 21.6% | 14.6% | 24% | 18.1% | 32.2% | 9.4% | 15.2% | 26.9% |
| 4. Kunming | City | 120 (59) | 18.3% | 29.2% | 11.7% | 35.8% | 11.7% | 35.8% | 3.3% | 44.2% |
| 5. Dali | City | 61 (25) | 23% | 19.7% | 16.4% | 22.2% | 19.7% | 23% | 29.5% | 11.5% |
| 6. Qiubei | City | 72 (19) | 9.7% | 9.7% | 11.1% | 13.9% | 12.5% | 12.5% | 12.5% | 13.9% |
| 7. Kunming (Jinning) | Peri | 141 (53) | 12.1% | 26.2% | 7.8% | 30.5% | 11.3% | 26.2% | 83% | 17% |
| 8. Dali | Peri | 60 (34) | 30% | 28.3% | 16.7% | 41.7% | 11.7% | 46.7% | - | 58.3% |

**TABLE H2:** FINANCING FROM HOUSEHOLD AND PROJECT SOURCES

| Site | Rural/ urban | Number of households interviewed | Household contribution | | Value of household inputs | | | Project value input (USD) |
|---|---|---|---|---|---|---|---|---|
| | | | Yes | No | Cash (USD) | Labor (days) | Materials (USD) | |
| 1. Kunming | Rural | 151 (54) | 0.54 | 0.34 | 131.46 | 2.00 | 141.85 | 99.69 |
| 2. Dali | Rural | 133 (59) | 0.38 | 0.38 | 66.31 | 1.50 | 27.23 | 1,181.07 |
| 3. Qiubei | Rural | 171 (75) | 0.50 | 0.18 | 141.56 | 2.00 | 32.21 | 94.86 |
| 4. Kunming | City | 120 (59) | 0.28 | 0.43 | 160.88 | 2.00 | 19.32 | 280.77 |
| 5. Dali | City | 61 (25) | 0.71 | 0.28 | 202.60 | 1.50 | 463.03 | 130.14 |
| 6. Qiubei | City | 72 (19) | 0.47 | 0.35 | 262.48 | 2.00 | 167.62 | 1,182.39 |
| 7. Kunming (Jinning) | Peri | 141 (53) | 0.55 | 0.32 | 62.65 | 1.00 | 84.47 | 123.70 |
| 8. Dali | Peri | 60 (34) | 0.28 | 0.53 | 519.39 | 1.00 | 150.63 | 157.37 |

**TABLE H3:** APPROPRIATE TECHNOLOGY

| Site | Rural/ urban | Number of house-holds in-terviewed | % households with insufficient water for flushing | | % households with pit flooding | | % households with pit overflow | |
|---|---|---|---|---|---|---|---|---|
| | | | Sometimes | Often | Sometimes | Often (rainy season) | Sometimes | Often (rainy season) |
| 1. Kunming | Rural | 151 | 1.3% | 1.3% | 0.7% | 0.7% | 2% | 0.7% |
| 2. Dali | Rural | 133 | 1.5% | 5.2% | 0 | 1.5% | 0.8% | 1.5% |
| 3. Qiubei | Rural | 171 | 1.6[illegible] | 4.5[illegible] | 4.7% | 2.3% | 4.7% | 9.1% |
| 4. Kunming | City | 120 | 0.8% | 3.3% | - | - | 0.8% | 0.8% |
| 5. Dali | City | 61 | 3.3% | 3.3% | - | - | - | - |
| 6. Qiubei | City | 72 | 4.2% | 1.4% | - | 1.4% | 1.4% | 1.4% |
| 7. Kunming (Jinning) | Peri | 141 | 1.4% | 1.4% | 0.7% | 0.7% | 1.4% | 0.7% |
| 8. Dali | Peri | 60 | 3.3% | 3.3% | - | - | - | - |

**TABLE H4:** ACTUAL PROGRAM PERFORMANCE IN RELATION TO KEY SELECTED INDICATORS FOR PROGRAM EFFECTIVENESS

| Impact | Indicator | Kunming (Rural) | Dali (Rural) | Qiubei (Rural) | Kunming (City) | Dali (City) | Qiubei (City) | Kunming (Peri) | Dali (Peri) |
|---|---|---|---|---|---|---|---|---|---|
| Health (sanitation intervention) | % household members using improved toilet regularly | 65.9% | 44.7% | 51.4% | 82.9% | 70.4% | 77.8% | 62.9% | 81.5% |
| Health (hygiene intervention) | % households washing hands after defecation | 88.1% | 69.9% | 55% | 75% | 78.7% | 77.8% | 90.1% | 71.7% |
| | % latrines with signs of feces around toilet | 23.8% | 15.8% | 12.3% | 4.3% | 29.5% | 4.2% | 34.8% | 0 |
| Water treatment | % households using non-boiling household water treatment methods | 4.6% | 4.6% | 32.7% | 6.7% | 3.3% | 25% | 4.3% | 5% |
| Access time | % household members using own toilet instead of off-plot options<br>Men<br>Women<br>Children 5-14<br>Children 0-4 | 88.6% | 85.1% | 75.7% | 82.9% | 81.5% | 77.8% | 68.6% | 81.5% |
| Reuse | Own use: % households applying human excreta in own land or using human excreta for biogas | 63.6% | 85.1% | 75.7% | 26.8% | 37% | 14.8% | 25.7% | 33.3% |
| Intangibles | Average score (as % of maximum score of 5) of satisfaction questions | 3.18 | 3.78 | 3.24 | 4.18 | 2.80 | 4.02 | 2.75 | 4.28 |
| External environment | Average score (as % of maximum score of 5) of external environment questions relating to sewage | 3.23 | 2.86 | 2.57 | 4.34 | 2.93 | 3.42 | 3.24 | 3.01 |

# ANNEX I: CBA AND CEA RESULTS

**TABLE I1:** SITE 6 - RURAL LUQUAN EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET"

| Efficiency measure | Scenario | Pit latrine | Septic tank |
|---|---|---|---|
| No. observations (households) | | 33 | 117 |
| COST-BENEFIT MEASURES | | | |
| Benefits per 1 US$ input ($) | Ideal | 11.1 | 7.1 |
| | Actual | 6.6 | 4.3 |
| Internal rate of return (%) | Ideal | na | na |
| | Actual | na | 2.2 |
| Payback period (years) | Ideal | na | na |
| | Actual | na | 1.5 |
| Net present value ($) | Ideal | 725.9 | 884.6 |
| | Actual | 401.8 | 481.1 |
| COST-EFFECTIVENESS MEASURES | | | |
| Cost per DALY averted ($) | Ideal | 254.5 | 328.6 |
| | Actual | 386.2 | 498.6 |
| Cost per case averted ($) | Ideal | 2.3 | 2.9 |
| | Actual | 3.4 | 4.5 |
| Cost per death averted ($) | Ideal | 4,577.8 | 5,904.5 |
| | Actual | 6,946.6 | 8,959.7 |

**TABLE I2:** SITE 7 - RURAL DALI EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET"

| Efficiency measure | Scenario | Shared | Pit latrine | UDDT | Biogas | Septic tank |
|---|---|---|---|---|---|---|
| No. observations (households) | | 7 | 49 | 9 | 13 | 52 |
| COST-BENEFIT MEASURES | | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 8.3 | 13.1 | 14.5 | 10.6 | 7.9 |
| | Actual | 5.1 | 9.4 | 9.4 | 6.6 | 5.5 |
| Internal rate of return (%) | Ideal | na | na | na | na | na |
| | Actual | na | na | na | na | 7.1 |
| Payback period (years) | Ideal | na | na | na | na | na |
| | Actual | na | na | na | na | 1.2 |
| Net present value ($) | Ideal | 407.1 | 766.8 | 1,065.2 | 1,078.4 | 935.6 |
| | Actual | 229.2 | 533.8 | 663.0 | 629.0 | 606.2 |
| COST-EFFECTIVENESS MEASURES | | | | | | |
| Cost per DALY averted ($) | Ideal | 196.8 | 224.5 | 176.6 | 252.8 | 303.9 |
| | Actual | 328.1 | 533.8 | 294.3 | 421.4 | 506.5 |
| Cost per case averted ($) | Ideal | 1.7 | 1.9 | 1.5 | 2.2 | 2.6 |
| | Actual | 2.8 | 3.2 | 2.6 | 3.7 | 4.4 |
| Cost per death averted ($) | Ideal | 3,569.9 | 4,070.6 | 3,198.4 | 4,580.1 | 5,504.9 |
| | Actual | 5,949.9 | 6,784.3 | 5,330.7 | 7,633.5 | 9,174.9 |

**TABLE I3:** SITE 8 – RURAL QIUBEI EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET"

| Efficiency measure | Scenario | Shared | Pit latrine | UDDT | Biogas | Septic tank |
|---|---|---|---|---|---|---|
| No. observations (households) | | 7 | 36 | 5 | 30 | 45 |
| COST-BENEFIT MEASURES | | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 12.1 | 14.4 | 15.5 | 11.7 | 8.5 |
| | Actual | 6.8 | 8.8 | 9.3 | 7.1 | 5.0 |
| Internal rate of return (%) | Ideal | na | na | na | na | na |
| | Actual | na | na | na | na | 3.8 |
| Payback period (years) | Ideal | na | na | na | na | na |
| | Actual | na | na | na | na | 1.3 |
| Net present value ($) | Ideal | 562.8 | 777.4 | 1,105.3 | 1,123.8 | 977.8 |
| | Actual | 295.6 | 456.3 | 633.7 | 640.7 | 523.9 |
| COST-EFFECTIVENESS MEASURES | | | | | | |
| Cost per DALY averted ($) | Ideal | 124.3 | 142.0 | 118.6 | 163.0 | 203.2 |
| | Actual | 241.8 | 276.2 | 230.7 | 317.1 | 395.4 |
| Cost per case averted ($) | Ideal | 1.2 | 1.3 | 1.1 | 1.5 | 1.9 |
| | Actual | 2.2 | 2.6 | 2.2 | 3.0 | 3.7 |
| Cost per death averted ($) | Ideal | 2,236.7 | 2,555.3 | 2,132.7 | 2,931.4 | 3,655.4 |
| | Actual | 4,351.5 | 4,971.4 | 4,149.2 | 5,703.1 | 7,111.7 |

**TABLE I4:** SITE 1 – URBAN KUNMING EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET"

| Efficiency measure | Scenario | Septic tank | Sewerage |
|---|---|---|---|
| No. observations (households) | | 85 | 33 |
| COST-BENEFIT MEASURES | | | |
| Benefits per 1 US$ input ($) | Ideal | 3.5 | 2.6 |
| | Actual | 2.4 | 1.8 |
| Internal rate of return (%) | Ideal | 1.3 | 0.7 |
| | Actual | 0.5 | 0.3 |
| Payback period (years) | Ideal | 1.8 | 2.6 |
| | Actual | 3.1 | 4.6 |
| Net present value ($) | Ideal | 390.9 | 332.1 |
| | Actual | 212.7 | 168.0 |
| COST-EFFECTIVENESS MEASURES | | | |
| Cost per DALY averted ($) | Ideal | 654.7 | 904.2 |
| | Actual | 1,091.1 | 1,408.0 |
| Cost per case averted ($) | Ideal | 6.3 | 8.6 |
| | Actual | 10.4 | 13.5 |
| Cost per death averted ($) | Ideal | 11,725.9 | 11,725.9 |
| | Actual | 19,543.1 | 25,218.9 |

**TABLE I5:** SITE 2 – URBAN DALI EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET"

| Efficiency measure | Scenario | Public toilet | Pit latrine | Septic tank | Sewerage |
|---|---|---|---|---|---|
| No. observations (households) | | 16 | 13 | 21 | 11 |
| COST-BENEFIT MEASURES | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 6.7 | 7.2 | 4.2 | 3.2 |
| | Actual | 4.5 | 5.1 | 2.9 | 2.1 |
| Internal rate of return (%) | Ideal | na | na | 2.2 | 1.1 |
| | Actual | na | na | 0.8 | 0.4 |
| Payback period (years) | Ideal | na | na | 1.5 | 2.0 |
| | Actual | na | na | 2.4 | 3.6 |
| Net present value ($) | Ideal | 495.4 | 418.3 | 475.9 | 426.2 |
| | Actual | 305.0 | 275.4 | 278.2 | 218.6 |
| COST-EFFECTIVENESS MEASURES | | | | | |
| Cost per DALY averted ($) | Ideal | 334.9 | 407.9 | 562.0 | 752.5 |
| | Actual | 558.1 | 679.9 | 936.7 | 1,317.1 |
| Cost per case averted ($) | Ideal | 3.0 | 3.6 | 5.0 | 6.7 |
| | Actual | 5.0 | 6.0 | 8.3 | 11.7 |
| Cost per death averted ($) | Ideal | 6,152.0 | 7,507.5 | 10,325.4 | 13,824.8 |
| | Actual | 10,253.4 | 12,512.5 | 17,209.1 | 24,197.1 |

**TABLE I6:** SITE 3 – URBAN QIUBEI EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET"

| Efficiency measure | Scenario | Shared | Pit latrine | UDDT | Private septic tank |
|---|---|---|---|---|---|
| No. observations (households) | | 2 | 13 | 3 | 50 |
| COST-BENEFIT MEASURES | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 6.5 | 8.5 | 9.5 | 5.4 |
| | Actual | 3.9 | 5.6 | 5.7 | 3.5 |
| Internal rate of return (%) | Ideal | na | na | na | 7.4 |
| | Actual | 7.0 | na | na | 1.2 |
| Payback period (years) | Ideal | na | na | na | 1.2 |
| | Actual | 1.2 | na | na | 1.9 |
| Net present value ($) | Ideal | 298.8 | 479.0 | 725.8 | 600.9 |
| | Actual | 157.3 | 295.5 | 401.7 | 339.0 |
| COST-EFFECTIVENESS MEASURES | | | | | |
| Cost per DALY averted ($) | Ideal | 193.6 | 226.3 | 193.3 | 310.4 |
| | Actual | 322.7 | 377.1 | 322.2 | 517.3 |
| Cost per case averted ($) | Ideal | 1.9 | 2.2 | 1.9 | 3.0 |
| | Actual | 3.2 | 3.7 | 3.2 | 5.1 |
| Cost per death averted ($) | Ideal | 3,498.7 | 4,089.2 | 3,497.1 | 5,614.4 |
| | Actual | 5,831.2 | 6,815.4 | 5,828.5 | 9,357.4 |

**TABLE I7:** SITE 4 – PERI-URBAN KUNMING EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET"

| Efficiency measure | Scenario | Shared | Pit latrine | UDDT | Septic tank |
|---|---|---|---|---|---|
| No. observations (households) | | 55 | 12 | 15 | 58 |
| COST-BENEFIT MEASURES | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 5.2 | 6.3 | 7.4 | 3.8 |
| | Actual | 3.3 | 4.1 | 4.3 | 2.4 |
| Internal rate of return (%) | Ideal | na | na | na | 1.5 |
| | Actual | 2.9 | 12.9 | na | 0.5 |
| Payback period (years) | Ideal | na | na | na | 1.7 |
| | Actual | 1.4 | 1.1 | na | 3.1 |
| Net present value ($) | Ideal | 236.5 | 368.4 | 550.6 | 416.9 |
| | Actual | 125.7 | 211.9 | 289.4 | 209.8 |
| COST-EFFECTIVENESS MEASURES | | | | | |
| Cost per DALY averted ($) | Ideal | 341.7 | 425.5 | 334.4 | 569.7 |
| | Actual | 569.4 | 709.2 | 557.4 | 949.4 |
| Cost per case averted ($) | Ideal | 3.1 | 3.9 | 3.1 | 5.2 |
| | Actual | 5.2 | 6.5 | 5.1 | 8.7 |
| Cost per death averted ($) | Ideal | 6,252.9 | 7,787.2 | 6,110.5 | 10,408.1 |
| | Actual | 10,421.4 | 12,978.6 | 10,184.2 | 17,346.8 |

**TABLE I8:** SITE 5 – PERI-URBAN DALI EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARED TO "NO TOILET"

| Efficiency measure | Scenario | Shared | Pit latrine | UDDT | Septic tank |
|---|---|---|---|---|---|
| No. observations (households) | | 16 | 17 | 9 | 17 |
| COST-BENEFIT MEASURES | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 9.2 | 8.6 | 11.0 | 5.4 |
| | Actual | 6.0 | 5.7 | 6.9 | 3.5 |
| Internal rate of return (%) | Ideal | na | na | na | 8.7 |
| | Actual | na | na | na | 1.2 |
| Payback period (years) | Ideal | na | na | na | 1.1 |
| | Actual | na | na | na | 1.9 |
| Net present value ($) | Ideal | 455.9 | 503.4 | 790.1 | 649.4 |
| | Actual | 277.4 | 314.0 | 461.7 | 369.5 |
| COST-EFFECTIVENESS MEASURES | | | | | |
| Cost per DALY averted ($) | Ideal | 200.2 | 240.7 | 790.1 | 335.4 |
| | Actual | 333.7 | 401.1 | 300.4 | 559.1 |
| Cost per case averted ($) | Ideal | 1.8 | 2.2 | 1.6 | 3.0 |
| | Actual | 3.0 | 3.6 | 2.7 | 5.0 |
| Cost per death averted ($) | Ideal | 3,689.4 | 4,435.6 | 3,317.2 | 6,173.5 |
| | Actual | 6,149.0 | 7,392.7 | 5,528.6 | 10,289.2 |

**TABLE I9:** SITE 8 – RURAL QUIBEI AREA EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARING DIFFERENT POINTS ON THE SANITATION LADDER (US$, YEAR 2009)

| Efficiency measure | Scenario | Moving from shared to | | | Moving from Pit latrine to (US$) | | |
|---|---|---|---|---|---|---|---|
| | | Pit latrine | UDDT | Biogas | UDDT | Biogas | Septic tank |
| COST-BENEFIT MEASURES | | | | | | | |
| Benefits per 1 US$ input ($) | Ideal | 3.8 | 4.5 | 7.3 | 4.5 | 5.0 | 2.1 |
| | Actual | 2.9 | 0.7 | 1.67 | 0.7 | 0.9 | na |
| Internal rate of return (%) | Ideal | 5.1 | na | na | na | 1.8 | 0.4 |
| | Actual | 1.5 | na | 0.3 | na | 0.0 | na |
| Payback period (years) | Ideal | 1.2 | na | na | na | 1.6 | 3.9 |
| | Actual | 1.7 | na | 4.9 | na | na | na |
| Net present value ($) | Ideal | 163.6 | 269.7 | 339.2 | 269.7 | 314.5 | 142.3 |
| | Actual | 109.7 | (21.4) | 36.6 | (21.4) | (14.3) | (131.2) |
| COST-EFFECTIVENESS MEASURES | | | | | | | |
| Cost per DALY averted ($) | Ideal | na | 325.1 | 230.4 | 325.1 | 335.4 | 557.2 |
| | Actual | na | 632.5 | 448.2 | 632.5 | 869.3 | 1,084.0 |
| Cost per case averted ($) | Ideal | na | 3.1 | 2.2 | 3.1 | 3.2 | 5.3 |
| | Actual | na | 6.0 | 4.2 | 6.0 | 8.2 | 10.2 |
| Cost per death averted ($) | Ideal | na | 5,840.3 | 4,139.2 | 5,840.3 | 6,025.9 | 10,010.4 |
| | Actual | na | 11,362.4 | 8,052.9 | 11,362.4 | 15,617.9 | 19,475.4 |

**TABLE I10:** SITE 1 – URBAN KUNMING AREA EFFICIENCY MEASURES FOR MAIN GROUPINGS OF SANITATION INTERVENTIONS, COMPARING DIFFERENT POINTS ON THE SANITATION LADDER (US$, YEAR 2009)

| Efficiency measure | Scenario | Moving from septic tank to sewerage (US$) |
|---|---|---|
| COST-BENEFIT MEASURES | | |
| Benefits per 1 US$ input ($) | Ideal | na |
| | Actual | na |
| Internal rate of return (%) | Ideal | na |
| | Actual | na |
| Payback period (years) | Ideal | na |
| | Actual | na |
| Net present value ($) | Ideal | (1,453.6) |
| | Actual | (1,358.1) |
| COST-EFFECTIVENESS MEASURES | | |
| Cost per DALY averted ($) | Ideal | 6,176.8 |
| | Actual | 9,617.9 |
| Cost per case averted ($) | Ideal | 59.1 |
| | Actual | 92.0 |
| Cost per death averted ($) | Ideal | 110,636.0 |
| | Actual | 172,272.9 |

wsp
water and
sanitation program